Chapter III: Affected Environment

Introduction

Yosemite National Park occupies about 1,170 square miles, or 748,955 acres (302,816 hectares), on the western slope of the Sierra Nevada, the highest and most continuous mountain range in California. The Sierra Nevada runs half the length of the state, dividing the Central Valley of central and northern California from the arid, western edge of the Great Basin to the east. Yosemite National Park lies within three counties – Mariposa, Tuolumne, and Madera – and abuts a fourth, Mono. The park shares boundaries with the Stanislaus, Sierra, Inyo, and Toiyabe National Forests. Ninety-four percent of the park (about 704,624 acres) is designated Wilderness.

Elevations in the park rise to 13,114 feet (3,998 m) near the eastern boundary, and drop to 2,127 feet (648 m) at the western boundary. This wide elevation range supports a variety of environments, each with distinct climatic conditions, vegetation, and animal life. Yosemite, like much of California, has a Mediterranean climate. Cool, moist winters and hot, dry summers prevail. The extreme differences in elevation and terrain affect both temperatures and precipitation. At higher elevations, most of the precipitation falls as snow.

Elevation and weather patterns result in large-scale vegetation zones along the north-south axis of the Sierra. On the west side, forest types change with increasing elevation from live oak to mixed conifer to mountain hemlock and pine at high elevations. Straddling the crest of the Sierra Nevada is a zone of subalpine and alpine vegetation. Secondary vegetation patterns are created by deep river canyons and the east-west orientation of watersheds that drain the Sierra Nevada. The range contains the headwaters of 24 major east-west river basins, two of which are in the park—the Merced and the Tuolumne Rivers.

Fire ignited by lightning and American Indians prior to the mid-1800s has influenced ecosystems in the Yosemite for millennia. Fire has affected plant and animal life, insect outbreak and disease cycles, wildlife habitat, and soil and nutrient cycling (U.C. Davis 1996b). In most low-elevation oak woodland and conifer forest types, fires were frequent. Fires collectively covered large areas and burned for months at a time. Most fires were of a low to moderate intensity, though patterns of severity were complex and fires were at times extreme. Over the last 150 years, fire suppression and changes in land use have dramatically changed fire regimes and consequently altered ecological structure and function in plant communities. Live and dead fuels in conifer forests, especially at lower elevations, are more abundant and continuous than in the past.

Humans have been a part of Sierra Nevada ecosystems for at least 10,000 years. Numerous, distinct American Indian cultures were widely distributed throughout the region well before settlement by Euro-Americans in the mid-19th century. Although the record is incomplete, archaeological evidence indicates that, prior to the 1850s, the American Indian population in the Sierra Nevada may have been as large as 90,000 to 100,000 people (Anderson and Moratto 1996).

The human population of the Sierra Nevada doubled between 1970 and 1990. Official projections indicate that the 1990 Sierra Nevada population of 650,000 will triple by the year 2040. Projected population trends show that more and more homes will be intermixed with flammable wildlands. Unless hazardous fuels are reduced more and more homes and people will be at high risk of loss from wildland fire. Only about one-third of the Sierra Nevada is privately owned.

The Sierra Nevada region is a popular tourist destination, containing some of the world's most renowned natural features. Annually, millions of visitors from around the country and the world are drawn to destinations like Lake Tahoe, Mono Lake, Yosemite National Park, and Sequoia and Kings Canyon National Parks.

Wildland Fire Management Situation

Wildland fires can potentially burn throughout the year in Yosemite, but the general fire season is May to November, when fuels are driest and the weather is more conducive to fires starting and spreading. The suppression of wildland fires for the last 80 to 100 years has changed the forests in Yosemite by allowing an accumulation of fuels. In what once were forests with a high frequency, low-severity fire regime, fire suppression has resulted in forests prone to high-severity fires. During the 1990's, Yosemite experienced three of the largest and most severe fires in the history of the park: the Steamboat and A-Rock Fires (22,000 acres) in 1990, and the Ackerson Fire (47,000 acres) in 1996. No evidence exists that these types of large, stand-replacing fires had ever previously occurred in the park (van Wagtendonk 2000).

Since 1972, approximately 75% of the park has been managed to allow wildland fires to burn in a "Prescribed Natural Fire Zone." Another 8% has been managed as a "Conditional Zone" where fires have been allowed to burn under some conditions. Almost 80,000 acres have burned in 30 years. Fires that start within these zones or fires that burn into these zones from neighboring public land are managed for resource benefits.

The Prescribed Natural Fire Zone extends from the northwest park boundary near Kibbie Creek and Lake Eleanor, skirts around Yosemite Valley and the southwest corner of the park, and terminates at Chiquito Pass on the southern boundary (see map 2-12). Natural and human-caused barriers and prominent topographic features form the western edge of this zone, while the park boundary forms the north, east, and south edges. Wildland fire is the primary fire management tool, although prescribed fire may be used. Hand thinning has been used to protect values at risk such as backcountry camps, cabins, and archaeological resources.

The other 17% of the park is in a "Suppression Zone." This area encompasses the western edge of the park, including the El Portal Administrative Site. Most of the park's developed areas are within this zone, including Hodgdon Meadow, Aspen Valley, Crane Flat, Foresta, El Portal, Yosemite Valley, Glacier Point, Wawona, and Yosemite West which is adjacent to the west boundary. All of the park's sequoia groves (Tuolumne, Merced, and Mariposa) are also within this zone. Unplanned ignitions that occur within this zone are suppressed, using *appropriate management response* strategies.

This concept offers managers a full spectrum of responses based on objectives, environmental and fuel conditions, constraints, safety, and the ability to accomplish objectives. It includes wildland fire suppression at all levels, including aggressive initial attack. Use of this concept dispels the interpretation that there is only one way to respond to each set of circumstances (Zimmerman and Bunnell 1998). Most prescribed fires and fuel reduction techniques take place in this zone, especially in and around developed areas and Special Management Areas (sequoia groves, wildland/urban interface, and boundary areas). Since 1970, when the prescribed fire program was initiated, through 2001, 43,065 acres have been burned.

Because Yosemite has distinct wet and dry seasons, the fire season is concentrated during the dry, hot summer. In the upper elevations, moisture levels in dead and down fuel can remain high late into the summer, resulting in a short fire season. The average number of years between fires, or *fire return interval*, ranges from 4 to 508 years in the upper elevations (above 8000 feet) depending on vegetation type. In the mid-elevations, at 5000 to 8000 feet, fire return intervals range from 3 to 75 years, depending on vegetation type. At lower elevations fire return intervals can range from 1 to 60 years, again depending on vegetation type.

The park averages 55 wildland fire starts per year, most of which are from lightning (map 3-1). Most starts go out quickly or are contained at less than 10 acres. In the past 10 years, the consequences of suppressing fires, with the resultant build-up of fuels, have exacerbated fire danger, especially at lower elevations along the park's western boundary. During fire season, fires starting in early afternoon on steep slopes, when vegetation is dry, have the potential to grow large rapidly, despite aggressive initial attack. When slope, wind, and temperature are all in alignment, fires can burn with rapid rates of spread and high flame lengths through the abundant, continuous fuels. This problem becomes more complex when summer thunderstorms cause gusty, erratic winds and multiple ignitions on the same day.

During dry conditions in places where fuels are not continuous, *spotting*, or fires started at a distance from the main fire by wind-blown embers, can also facilitate fire spread and resistance to control. For example, an individual tree or a group of trees may *torch* (go up in flames) and spread airborne embers one half mile or more. Trees in these areas might then ignite, torch, and then spread additional embers—thus starting more spot fires. Fires that spread by spotting are difficult to control.

Another potential control problem unique to this portion of the Sierra Nevada are strong easterly winds called foehn or Mono winds. However, there is no record or evidence of fires being driven by Mono winds in the park.

Biological Environment

Vegetation and Fire Ecology

The vegetation of Yosemite is varied and complex. At least 1,374 vascular plant species and numerous bryophytes and lichens occur in the park (NPS 1997a). Yosemite's forests include three world record trees: the largest red fir and white fir, and the world's tallest pine tree—a sugar pine. Approximately 54% of Yosemite National Park supports high quality, late successional forest (Franklin and Fites-Kaufmann 1996). A number of species are considered globally or locally rare. The park has five plants that are species of concern, no federally listed plant species, four State of California listed species, and 109 special-status plant species (NPS 1997a; Appendix 11).

The vegetation zones of the park follow general elevation bands (Sawyer and Keeler-Wolf 1995). At about 2000 feet, slopes are covered with chaparral and oak woodland. Lower montane mixed-conifer forests range from about 3000 to 6700 feet, changing to upper montane conifer forests from 6000 to 10,000 feet in elevation. Subalpine conifer forests occur from 8,000 to 11,000 feet, although alpine communities dominate above 10,000 feet.

For the purpose of this plan, data from the park's 1934 vegetation map was reclassified so that it matched current vegetation community typology while grouping vegetation communities by fuel type and fire behavior. The groupings are based on the analysis for the *Vegetation Management Plan* (based on 1934 data), a map of the dominant species from the 1934 data, the park's 1982 Botti vegetation map, and a determination by fire professionals on the similarity of potential fire behavior in each type. Appendix 10 includes a table showing how the various *Vegetation Management Plan* types were grouped into the 15 fire management vegetation types.

Neighborhood analyses were performed for meadows, riparian vegetation types, and western juniper. These were lumped into the fire management vegetation types according to their physical proximity. For example, if a subalpine meadow adjoins a lodgepole pine forest, it would be lumped with the forest since the meadow would be likely to burn if the forest were ignited. If, however, the meadow were surrounded by barren rock, it would be lumped with the rock since it would be unlikely to be ignited.

The 15 vegetation types and the bare rock and water categories are listed in Table 3.1 for the 747,955 acres in Yosemite National Park and in Table 3.2 for the 1,137 acres in the El Portal Administrative Site. The types are listed generally from higher to lower elevation. More detailed descriptions for each type are found in the *Vegetation Management Plan*. For convenience, types were further grouped, based on elevation.

Table III-1
Vegetation groups, corresponding fire vegetation types, and acreage for Yosemite National Park

Yosemite National Park		
Vegetation Group	Vegetation Type	Acres
Subalpine forests	Whitebark pine/mountain hemlock forest	87,582
	Lodgepole pine forest	175,516
Upper montane forests	Red fir forest	68,125
	Western white pine/Jeffrey pine forest	132,708
	Montane chaparral	15,137
Lower montane forests	Giant sequoia/mixed-conifer forest	218
	White fir/mixed-conifer forest	46,871
	Ponderosa pine/mixed-conifer forest	33,998
	Ponderosa pine/bear clover forest	33,846
	California black oak woodland	3,156
	Canyon live oak forest	21,344
Montane meadow	Dry montane meadow	1,530
Foothill woodlands	Foothill pine/live oak/chaparral woodland	6,984
	Foothill chaparral	1,768
Barren	Bare rock	112,022
	Water	7,150
Total Acres		**747,955**

Table III-2
Vegetation groups, corresponding fire vegetation types, and acreage for the El Portal Administrative Site

El Portal Administrative Site		
Vegetation Group	Vegetation Type	Acres
Lower montane forests	Ponderosa mixed-conifer forest	372
	Canyon live oak forest	129
Foothill woodlands	Foothill pine-live oak-chaparral woodland	146
	Foothill chaparral	17
	Blue oak woodland	473
Total Acres		**1,137**

Fuel Models

Vegetation types are represented by fire behavior fuel models. The models quantify the fuel bed characteristics and are used in fire behavior models to predict the likelihood of ignition, the rate of spread, and the intensity of fire in a vegetation type. Fuel models take into account fuel load, ratio of surface area to volume for each size class of fuel, the depth of the fuel bed, and fuel moisture, including the moisture at which a fire will not spread in that fuel. Fuels are roughly classified in Yosemite and El Portal as grass, brush, and conifers (see map 3.2). For fire behavior analysis, each vegetation type is assigned to at least one fuel model, depending on its characteristics (see table 3.3).

Table III-3
Fuel Models and Vegetation Types of Yosemite and El Portal

Fuel Model	Typical Fuel Complex	Corresponding Vegetation Types
	Grass/Grass Dominated	
1	Short Grass	dry montane meadow blue oak woodland
2	Trees with grass understory	lodgepole pine (substantial herbaceous understory) ponderosa pine/bear clover
3	Tall Grass	
	Chaparral and Shrub Fields	
4	Chaparral (6 feet)	whitebark pine/krummholz, pine/oak/chaparral woodlands (brush > 6′) foothill chaparral (brush > 6′)
5	Brush (2 feet)	western white pine/Jeffery pine w/ chaparral understory montane chaparral canyon live oak crown fires pine/oak/chaparral woodlands (brush < 6′) foothill chaparral (brush < 6′)
6	Dormant brush, hardwood slash	
7	Southern rough	
	Conifer	
8	Short-needled Conifer	whitebark pine and/or mountain hemlock lodgepole pine (fuel loads ~30 tons/ac.) red fir giant sequoia white fir/mixed-conifer canyon live oak surface fires
9	Long-needled Conifer	western white pine/Jeffery pine ponderosa pine/mixed-conifer California black oak
10	Short-needled Conifer—heavy fuels	giant sequoia w/ heavy fuels white fir/mixed-conifer w/ heavy fuels

Vegetation Classification: Ecology and Natural Fire Conditions

Subalpine Forests

The subalpine zone includes whitebark pine and/or mountain hemlock forests and lodgepole pine forests (see map 2-1), which together occupy about 35% of the park. Characteristic tree species include lodgepole pine, mountain hemlock, and whitebark pine, with smaller amounts of red fir, western white pine, and western juniper (UC Davis 1996e). Although this zone receives approximately 35% of the lightning strikes in the park, fires are infrequent and rarely become large (van Wagtendonk 1991). These fires usually smolder or spread as low intensity surface fires.

Whitebark pine/mountain hemlock forest

Whitebark pine and mountain hemlock forests cover 87,582 acres of the park and comprises much of the subalpine forest from 9,600 to 11,000 feet. Pure stands of whitebark pine and intermixed stands of mountain hemlock, whitebark pine, and lodgepole are common. Mountain hemlocks occasionally form pure stands on north-facing slopes and occur as low as 8,000 feet. At or near tree line, this community can be open forest or dense shrub like krummholz. Fuel loads average about 44 tons per acre underneath clusters of whitebark pines and about 54 tons per acre underneath mountain hemlock (van Wagtendonk et al. 1998). Fuel Model 8 (see table 3.3) is most appropriate for this type, although Fuel Model 4 should be used for krummholz stands of whitebark pine.

Between 1930 and 2000, 56 lightning fires burned a total of 121 acres of the whitebark pine/ mountain hemlock type once and less than one acre twice. The largest area burned in the type by a single lightning fire was 20 acres. Over the same time period, three human-caused fires burned slightly more than one-quarter acre in the whitebark pine/mountain hemlock type, and no prescribed burns have been conducted. Based on the area in the park burned by all lightning-caused fires that were allowed to burn in whitebark pine forest between 1972 and 1993, van Wagtendonk (1994) calculated that the *fire rotation* (the number of years it would take to burn all of the type in Yosemite at the present rate of burning) would be over 23,000 years. Fire scar analyses of whitebark pine and mountain hemlock forests indicate that fire return intervals range from 4 to 508 years with a median of 187 year. Due to the long median and maximum return intervals for this group, the fire return interval departures (FRID) tend to be low with all of the type within the maximum and median fire return intervals ($FRID_{max/med} = 0$). This indicates existing vegetation does not have a severely altered fuel load or stand structure because of fire exclusion.

Lodgepole pine forest

Lodgepole pine forest is the most common vegetation type in the park covering 175,516 acres. It often grows in dense pure or almost pure stands of trees up to 130 feet tall. Lodgepole pine tolerates large variation in soil type and moisture conditions. It commonly occurs on rocky, well-drained soils from 6,800 to 10,400 feet and at lower elevations in cold-air drainages. It is nearly continuous between 8,500 and 10,000 feet and in long narrow stringers at lower elevations. Fuel Model 8 best represents lodgepole pine forests where fuel loads average 30 tons per acre (van Wagtendonk et al. 1998). In areas where there is a substantial amount of herbaceous understory, Fuel Model 2 can be applied.

A total of 465 fires have burned 9,110 acres of lodgepole pine forest since 1930. Fires include 427 lightning fires, 25 human-caused fires, and 13 prescribed fires. Of the total area, 7,467 acres have burned once, 989 acres twice, and 157 acres three times. The largest area of lodgepole pine forest to burn with a single lightning fire was 773 acres in 1987. These fires usually remain as very low intensity surface fires, often spreading from log to log or smoldering in the thin, densely packed duff. The fire rotation is 764 years (van Wagtendonk 1994). Kiefer (1991) determined that fire return intervals for lodgepole pine forests range from four to 163 years with a median value of 102 years. Based on both the maximum and median fire return interval, all of the lodgepole pine forest has a FRID of zero ($FRID_{max/med}=0$). Consequently, the structure of this type does not appear to have been altered by fire exclusion.

Upper Montane Forests

The upper montane zone includes red fir forest, western white pine/Jeffrey pine forest, and montane chaparral and makes up about 30% of park vegetation. Characteristic trees include red fir, western white pine, Jeffrey pine, western juniper, and aspen (U.C 1996e). This zone receives 23% of the lightning strikes in the park, and fires are numerous, generally remain small, and are of low intensity (van Wagtendonk 1991). However, under extremely dry and windy conditions, large stand replacing fires can occur.

Red fir forest

Red fir forest covers 68,125 acres of the park and is associated with the areas of greatest snow accumulation in the park. This plant community dominates at elevations between

6,500 and 9,000 feet. Forests occur in large stands, separated by barren areas, ridges, meadows, or lower-elevation lodgepole pine forest. In drier sites and at lower elevations, it intergrades with Jeffrey pine and montane chaparral. Because fires have been suppressed, the community is currently shifting to favor more shade-tolerant red fir and moving into areas that were dominated by lodgepole pine, montane chaparral, and Jeffrey pine. Fuel loads are relatively high, averaging about 49 tons per acre (van Wagtendonk et al. 1998). Despite the heavy fuel loads, Fuel Model 8 best fits the red fir forest because surface fires are usually carried by fuels less than one inch in diameter.

Since 1930, 591 lightning fires have burned 16,767 acres, 18 human-caused fires have burned 1004 acres, and five prescribed fires have burned 307 acres of red fir forest. Out of the total 18,074 acres, 16,084 have burned only once, while 1,476 acres have burned twice, 81 acres three times, and one acre four times. The Lost Bear Fire that burned 1,265 acres of red fir forest in 1999 has been the largest to occur in this type. It would take 197 years to burn all of the red fir forest in Yosemite given the rate of burning that occurred between 1972 and 1993 in the Prescribed Natural Fire Zone (van Wagtendonk 1994). Return intervals determined from fire scars indicate a minimum of nine years, a median of 30 years, and a maximum of 92 years (Caprio and Lineback 1997). In red fir, 50,484 acres have missed one maximum fire return interval ($FRID_{max}$ = 1), while and additional 17,641 acres have not missed any ($FRID_{max}$ = 0). Minor departures in stand structure are beginning to occur.

Western white pine / Jeffrey pine forest

The park contains 132,708 acres of western white pine and Jeffrey pine forest. They grow in pure stands and intergraded with montane chaparral and other species. Both western white and Jeffrey pine tend to occur in dry sites. Western white pine grows from 8,000 to 10,000 feet. Trees are widely spaced and may have an understory of montane chaparral. Existing vegetation is probably within the natural range of variability. Jeffrey pine grows from 6,000 to 9,000 feet intergrading with montane chaparral, red fir, and white fir/mixed-conifer forest. Fuel loads range from 13 tons per acre for western white pine to 43 tons per acre for Jeffrey pine (van Wagtendonk et al. 1998). Fuel Model 9 can be used for both species, although in some cases Fuel Model 8 may be necessary for western white pine. In areas where montane chaparral exists in the understory, Fuel Model 5 is appropriate. Existing conditions at lower elevations and more mesic sites show an increase of shade-tolerant conifers, such as white fir, in the understory and accumulations of surface fuels.

The western white pine/Jeffrey pine forest burns frequently and fires burn with high intensity. Lightning is prevalent and has resulted in 893 fires burning 41,982 acres between 1930 and 2000. The largest number of acres of this type burned by a lightning was during the Starr King fire in 1974 when 3,274 acres burned. Forty-seven human-caused fires have burned an additional 6,385 acres, and 24 prescribed fires have restored 5,584 acres. Over 25% (34,477 acres) of the forest has been burned once. Reburns have been common and 6,884 acres have burned two times, 2,423 acres three times, 243 acres four times, and 13 acres five times. About 21,071 acres of this type have burned in the last 12 years.

Fire return intervals are variable; some are very long because many of the stands are isolated by broad expanse of granite while others are short because of the presence of montane chaparral species that help spread fire. Taylor and Skinner (1998) reported a minimum fire return interval of four years, a median of 12 years, and a maximum of 96 years. If the maximum fire return interval is used, all of the type would have a FRID equal to zero ($FRID_{max}$=0). However, calculations based on the median fire return interval show that 15,929 acres have missed one interval ($FRID_{med}$ =1), 3,970 acres have missed two

($FRID_{med}$ =2), 326 acres have missed three ($FRID_{med}$ =3), 2,709 have missed four ($FRID_{med}$ =4), and 88,703 acres have missed five intervals ($FRID_{med}$ =5). This indicates that some of the existing vegetation has an increased fuel load and altered stand structure due to fire exclusion.

Montane Chaparral

Montane chaparral covers 15,137 acres of the park, normally on south facing slopes ranging from 5,500 to 9,500 feet. Dominant species include greenleaf manzanita, pinemat manzanita, mountain white thorn, huckleberry oak, and, at lower elevations, bitter cherry and chinquapin. Mature stands form dense brush fields between one and five feet in height. Fuel Model 5 best describes montane chaparral fuels, although this model under predicts flame length (van Wagtendonk and Botti 1984). This community intergrades with Jeffrey pine, red fir, and white fir/mixed-conifer forest types. The size and extent of the community has probably decreased with fire suppression. However, existing conditions show mature fields with higher densities of Jeffrey pine than in the historic range of variability.

Since 1930, lightning has ignited 126 fires that have burned 2,651 acres of montane chaparral. Eleven human-caused fires have burned 1,175 acres and 22 prescribed fires have burned 755 acres. The largest lightning fire to burn in montane chaparral covered 641 acres during the Le Conte fire in 1999. Of the total acreage, 2,787 acres have burned once, 874 acres have burned twice, 185 acres have burned three times, and six acres have burned four times. Skinner and Chang (1996) reported fire return intervals from 10 to 75 years with a median of 30 years. Based on the maximum fire return interval, all of the type had a FRID of zero ($FRID_{max}$ =0). However, the median return interval shows 430 acres that have missed one interval ($FRID_{med}$ =1) and 11,293 acres have missed two intervals ($FRID_{med}$ =2). This indicates that some of the existing vegetation has an increased fuel load and altered stand structure, including an increase of Jeffrey pine in unburned areas.

Lower Montane Forests

The lower montane zone, which includes giant sequoia, white fir, ponderosa pine/mixed-conifer forests, and ponderosa pine/bear clover forest, covers about 15% of the park. Dominant tree species include ponderosa pine, sugar pine, incense-cedar, and white fir. This zone also contains Douglas-fir/mixed-conifer forest, California black oak woodlands, canyon live oak forests, and dry montane meadows. The most common understory shrubs are white leaf manzanita and deerbrush.

Although the lower montane forest receive only 17% of the lightning strikes in the park, this mixed-conifer community experiences frequent, low-intensity fires (van Wagtendonk 1991). Nearly 100 years of fire suppression has resulted in a change from open forest to dense thickets of shade-tolerant tree species (including incense-cedar, white fir, and Douglas-fir) at the upper elevations of the zone and an increase in shrubs at the lower elevations. Under natural conditions, the return interval for fire is estimated to be from two to 35 years (NPS 1990b). Existing conditions, however, often generate fires of much greater intensity than under a natural fire regime.

Giant sequoia/mixed-conifer forest

Giant sequoia/mixed-conifer forest covers 218 acres in three groves found between 5,300 and 6,700 feet. Mariposa Grove, the largest of the groves, contains about 86% of the sequoias in the park. The giant sequoia type is a subset of the white fir/mixed-conifer forest, but because the ecological and cultural significance of this species this type is treated separately. The groves are Special Management Areas and are discussed in Chapter 1, Goals and Objectives. This type exists in micro sites that are remnants from extensive giant sequoia forests existing about 100,000 years ago (Raven and Axelrod 1979). Giant sequoia is currently limited in its distribution by soil moisture, water table, air temperature, and ecological tolerance of seedlings (Rundel 1972). The groves are wetter and more moist than typical in the white fir/mixed-conifer forest. Dominant species include giant sequoia, white fir, sugar pine, and incense-cedar. Broadleaf lupine and little-leaf ceanothus dominate the abundant shrub and herbaceous layer. Existing vegetation has more shade-tolerant seedling, pole, and small, overstory conifers, particularly white fir and incense-cedar, than would have been present historically. Fuel load averages 75 tons per acre and is evenly split between duff and woody fuels (van Wagtendonk et al. 1998). Fuel Model 8 best represents the giant sequoia forest, although Fuel Model 10 should be used for areas with heavy fuel concentrations.

Only one lightning fire has been recorded in the giant sequoia groves since 1930. That fire burned in the top of a single giant sequoia tree in 1976 and was extinguished. Two human-caused fires burned less than one acre. In 1971, prescribed burning in the groves started as a result of reports that fuel conditions threatened the survival of the giant sequoias. Since the initiation of the program, 14 prescribed fires have burned 241 acres in the Mariposa Grove, and three fires have burned nine acres in the Merced Grove. Of the three groves, 88 acres of giant sequoia have burned once, while 81 acres have burned twice, nine acres three times, two acres four times, and two acres five times. Fire scars have been used to determine fire return intervals for giant sequoias and found a minimum value of three years, a maximum value of 15 years, and a median value of 10 years. Only 82 acres have departed one interval from the maximum value ($FRID_{max}$ =1), while 45 acres have departed one interval ($FRID_{med}$ =1) and 80 acres have departed two intervals from the median value ($FRID_{med}$ =2). In addition, 36 acres surrounding the Clark Cabin have missed seven fire return intervals ($FRID_{med}$ =7). This shows that the recent burning in the groves has returned much of the area to within the natural range of variability. However, in the areas that have moderate to high departures from the median FRID, increased fuel loading and altered stand structure are seen.

White fir/mixed-conifer forest

White fir/mixed-conifer forest covers 46,871 acres, forming an almost continuous band of dense forest between 5,500 and 7,500 feet in elevation. Conditions vary from almost pure stands of white fir on north facing slopes to white fir mixed with co-dominant sugar pine, Jeffrey pine, Douglas-fir, and incense-cedar. Existing vegetation has thickets of shade-tolerant seedling, pole, and small, overstory conifers, particularly white fir and incense-cedar, that would not have been present historically. These thickets and a lack of adequate seedbed have limited sugar and Jeffrey pine regeneration as well. Fuel loads vary from 33 tons per acre for Douglas-fir to 46 tons per acre for sugar pine; white fir and incense-cedar fall in between with 41 and 43 tons per acre, respectively (van Wagtendonk et al. 1998). Fuel Model 8 is generally appropriate for white fir/mixed-conifer forests, and Fuel Model 10 can be used where heavy fuels exist (van Wagtendonk and Botti 1984).

Since 1930, 569 fires have burned 28,407 acres of white fir/mixed-conifer forest. Out of that total, 427 lightning fires have burned 20,436 acres, 25 human-caused fires have burned 625 acres, and 13 prescribed burns have restored fire to 7,387 acres. Although 22,426 acres have not burned in over 70 years, 20,000 acres have burned once, 3,797 acres twice, 448 acres three times, and 18 acres four times. The largest area of white fir/mixed-conifer forest to burn with a single lightning fire was 1,092 acres in the Walker fire in 1988. The fire rotation for white fir forests based on lightning fires allowed to burn in the Prescribed Natural Fire Zone between 1972 and 1993 was 82 years (van Wagtendonk 1994). Fire return intervals range from three years to 35 years with a median of eight years. Departures from the maximum fire return interval included 274 acres that have missed one interval ($FRID_{max}$ =1) and 22,429 acres that have missed two ($FRID_{max}$ =2). Based on the median fire return interval, 6,925 acres have missed one interval ($FRID_{med}$ =1) and 2,928 acres have missed two intervals ($FRID_{med}$ =2). Many areas have missed from three to seven intervals and 22,436 acres have missed eight intervals ($FRID_{med}$ =8). Much of this vegetation type shows moderate to high departures from median fire return intervals. The fuel load has increased and stand structure has been altered by an increase of seedlings, poles, and small, overstory white fir and incense-cedar.

Ponderosa pine/mixed-conifer forest

Ponderosa pine/mixed-conifer forest covers 33,998 acres of the park and forms a fairly continuous band between 3,000 and 5,500 feet in elevation. In the El Portal Administrative Site, this type covers 146 acres on north facing slopes down to 1,800 feet. It intergrades with several other vegetation types including white fir/mixed-conifer forest at higher elevations and ponderosa pine/bear clover forest, California black oak woodland, foothill pine/live oak/chaparral woodland, canyon live oak forest, and foothill chaparral at lower elevations. Ponderosa pine is a dominant species with white fir and California black oak as co-dominants. Mariposa manzanita and deerbrush are often found in forest openings. Existing vegetation has thickets of shade-tolerant seedling, pole, and small, overstory conifers; particularly white fir and incense-cedar, that would not have been present historically. Incense-cedar and white fir have increased in dominance in the overstory tree canopy as well. Continued fire exclusion in this forest will cause a type conversion from ponderosa pine to incense-cedar and white fir dominated forests. Ponderosa pine surface fuels average 57 tons per acre for ponderosa pine, 41 tons per acre for white fir, 43 tons per acre for incense-cedar, and 12 tons per acre for black oak (van Wagtendonk et al. 1998). Fuel beds dominated by ponderosa pine or black oak are best modeled by Fuel Model 9 (van Wagtendonk and Botti 1984). Surface fuels will continue to increase in the absence of periodic fire, and, combined with the thickets of understory vegetation, may lead to catastrophic fires.

In the ponderosa pine/mixed-conifer forest, fires burn regularly and with relatively low intensities. Since 1930, 341 lightning fires have burned 15,536 acres. Exclusive of the A-Rock and Steamboat fires in 1990, which were burning in unnaturally high surface and understory fuels under extreme weather conditions, the largest area of the park burned by a lightning fire in ponderosa pine/mixed-conifer forest occurred during the Eleanor fire in 1999 when 960 acres burned. The A-Rock fire burned 17 acres of this type in the El Portal Administrative Site. Nineteen human-caused fires have burned an additional 809 acres of the ponderosa pine/mixed-conifer type. This forest type has been the focus of much of the park's prescribed fire program. Seventy-nine prescribed burns have restored fire to 10,976 acres in the park, and nine burns have restored fire to 32 acres in the El Portal Administrative Site. Although 14,300 acres have not burned, 12,609 acres have burned once, 6,178 acres twice, 792 acres three times, 45 acres four times, and two acres have burned five times.

The fire rotation for this type, based on the small number of acres of ponderosa pine forests that were allowed to burn in the Prescribed Natural Fire Zone between 1972 and 1993, is 138 years (van Wagtendonk 1994). Compared to calculated fire return intervals, this number is unexpectedly high and indicates that these forests are falling further and further behind in maintaining their natural fire regime. Fire return intervals are short in this type, ranging from a low of three years to a high of 14 years, with a median of nine years (Kilgore and Taylor 1979). Departures from the maximum fire return interval range up to five missed intervals (14,399 acres) while the highest number of missed median return intervals is seven (14,403 acres). Much of this vegetation type shows moderate to high departures from median fire return intervals. The fuel loads has increased and stand structure altered by an increase of seedlings, poles, and small, overstory white fir and incense-cedar. Stands will be converted to white fir/mixed-conifer forest if fire is not reintroduced throughout the type.

Ponderosa pine/bear clover forest

Ponderosa pine/bear clover forest covers 33,846 acres of the park's south and west facing slopes and ridgelines between 3,000 and 5,500 feet. It intergrades with ponderosa pine/mixed-conifer forest at higher elevations and with California black oak, foothill pine/live oak/chaparral woodland, canyon live oak forest, and foothill chaparral at lower elevations. Ponderosa pine is a dominant species with California black oak and canyon live oak as common associates. The type is characterized by areas of almost continuous understory of bear clover. Existing vegetation has thickets of shade-tolerant seedling, pole, and small overstory conifers, particularly white fir and incense-cedar, that would not have been present historically. Incense-cedar and white fir have increased in dominance in the overstory tree layer. The vigor of California black oak overstory trees has been reduced and regeneration of this species is uncommon. Natural fuel loads were kept relatively low by periodic low intensity surface fires, but are currently accumulating in unburned areas. Typical fuel loads are 47 tons per acre for ponderosa pine and in areas where bear clover is present Fuel Model 2 is the best fit (van Wagtendonk and Botti 1984; van Wagtendonk et al. 1998). There is a large potential for type conversion due to the unnaturally high fuel loads and effects of high severity fires.

Fire is common in the ponderosa pine/bear clover forest. Between 1930 and 2000, 247 lightning fires burned 19,160 acres, 59 human-caused fires burned 1,494 acres, and 121 prescribed fires burned 11,619 acres. The largest lightning fire other than the A-Rock fire burned 1,247 acres in this type in 1987. Combined, these fires have resulted in 12,441 acres burning once, 7,201 acres burning twice, 1,731acres burning three times and 295 acres burning four times. An additional 40 acres have burned from five to seven times. Caprio and Swetnam (1995) reported a minimum fire interval of two years, and median of four years, and a maximum of 6 years. Because of the relatively short fire return intervals and years of fire suppression in this type, 12,169 acres have missed up to 11 maximum return intervals ($FRID_{max}$ =11) or 17 median intervals ($FRID_{med}$ =17). Much of this vegetation type shows moderate to high departures from median fire return intervals. The fuel load has increased and stand structure altered by an increase of seedlings, poles, and small, overstory white fir and incense-cedar. California black oak will continue to decrease in number and stands will be converted to white fir/mixed-conifer forest if fire is not reintroduced throughout the type.

California black oak woodland and forest

From 4,000 to 6,000 feet in elevation, 3,156 acres of the park are covered in California black oak woodland and forest. These are in almost pure stands or as the co-dominant species. It intergrades with ponderosa pine/bear clover at higher elevations and foothill pine/live oak/chaparral woodland and canyon live oak forest at lower elevations. It is rarely found without Ponderosa pine as a component. Other common trees found in this type include, incense-cedar and canyon live oak. Bear clover is a common shrub in this type, which often has a well developed understory. The extent and vegetation in this type have been severely altered by decades of fire suppression and the change in fire regime brought about by other human influences. This type composes less than 0.5% of all park land. In Yosemite Valley, black oak woodlands are estimated to cover less than 10% of the area indicated by 1860s photographs (Gibbens and Heady 1964). Existing vegetation has thickets of shade-tolerant seedling, pole, and small overstory conifers, particularly white fir and incense-cedar, that would not have been present historically. Ponderosa pine and other species now dominate the overstory while the vigor of California black oak overstory trees is reduced and regeneration of this species is uncommon. Fuel loads are low (12 tons per acre) underneath black oaks, and Fuel Model 9 is appropriate for those locations.

Because of the low fuel loads, low intensity surface fires with flame lengths less than one foot are typical. Only 24 lightning fires have ignited in the California black oak forest since 1930, and these fires burned only 353 acres. Three human-caused fires have burned an additional 81 acres, and 22 prescribed fires have been used to restore 868 acres of black oak forest. Repeated prescribed burning has resulted in some areas of black oak burning two or three times 158 acres and 27 acres, respectively). However, most the type has not burned at all (2,012 acres) or burned only once (959 acres). Fire return intervals are difficult to determine, but Stephens (1995) and Skinner and Chang (1996) believed that intervals from two to 18 years with a median of eight years would be appropriate. Based on those estimates, 2,013 acres of California black oak forest have a maximum FRID of three ($FRID_{max}$ =3) and a median FRID of eight ($FRID_{med}$ =8). Two thirds of this type has not burned and shows high departures from median fire return intervals. The fuel load has increased and stand structure altered by an increase of seedlings, poles, and small, overstory white fir and incense-cedar. California black oak will continue to decrease in number and stands will be converted to ponderosa pine/mixed-conifer forest if fire is not reintroduced throughout the type.

Canyon live oak forest

Canyon live oak forest covers 21,344 acres of the park on both north- and south-facing talus slopes. It often forms pure or almost pure stands between 2,500 and 5,000 feet in elevation. In the El Portal Administrative Site, the type covers an additional 129 acres down to 1,900 feet. Structure of the forest varies from low shrub-like trees on south-facing slopes to erect forest up to 65 feet in height in more mesic sites. Canyon live oak is the dominant species with some incense-cedar and California laurel but little understory vegetation. Information about historical vegetation composition and patterns for this type is lacking (UC Davis 1996e). Because of this we are unable to compare existing vegetation with a historic range of variability. Photographs of this type taken in the 1860s and 1870s in Yosemite Valley indicate that communities are denser today. Fuels have not been quantified in this type, but loads of up to 25 tons per acres seem reasonable. Fuel Model 5 is used for crown fires, while surface fires are best characterized by Fuel Model 8.

Frequent torching and occasional crown fires are typical for canyon live oak. Between 1930 and 2000, these forests have been ignited 108 times by lightning—the fires burned 10,510 acres. Human-caused fires are less common but larger. In Yosemite, 21 human-caused fires have burned 5,001 acres. A total of 22 prescribed fires in canyon live oak forests have burned 2,025 acres. Over half of the type in the park has been burned once (4,871 acres) or twice (5,596 acres), while only 661 acres have burned three times, and 94 acres have burned four times. No fires have burned in canyon live oak in the El Portal Administrative Site since 1930. The Le Conte fire burned 3,517 acres of canyon live oak forest in 1999. Taylor and Skinner (1998) determined fire return intervals for canyon live oak that range from seven years to 39 years with a median of 13 years. Departures from the maximum return interval include 10,615 acres that have missed only one interval ($FRID_{max}$ =1). However, half of this type shows high departures from median fire return intervals. The fuel load has increased and stand structure has been altered. Reduction of this fuel load should reduce the probability of high intensity fires moving into neighboring ecotypes.

Meadow

Montane meadow

Montane meadows cover 1,530 acres from 4,000 to 6,000 feet in elevation on fine-textured, continuously moist or wet soils. Some of these meadows dry out late in the growing season. This type is made up of grasses and sedges with sedges predominating in wetter areas. These areas are generally less than 100 acres in size and normally surrounded by California black oak or ponderosa pine/mixed-conifer and ponderosa pine/bear clover forest. Fuel loads are usually less than one ton per acre, making Fuel Model 1 the appropriate model.

Most of Yosemite's meadows are also classified as wetlands. They are included in this discussion of montane meadows to assure that fire management activities are discussed as they relate to all fire-dependent communities, including meadows. Meadows are also discussed under the heading wetlands, but meadows are only one of the types of sites that fall under that heading.

These meadows compose less than 0.5% of all park land and are ecologically and culturally significant. All areas have had severe encroachment by conifer species. One study of Yosemite Valley estimates that at least 50% of the meadows have succeeded to forest in the last 120 years (Ernst 1961). There is little information about historical vegetation composition and patterns for this type (SNEP 1996) so we are unable to compare existing vegetation with historic conditions. Kentucky bluegrass and other a non-native cool season grasses and non-native forbs are found throughout many of the montane meadows. Many of these communities, particularly in Yosemite Valley, have been altered by development and/or alteration of the hydrologic regime. Intensive ecological restoration efforts are on going in some of these areas.

Fires can burn rapidly through the grasses and flame lengths can range from two to 10 feet. Only 16 lightning fires have occurred in this type since 1930. Those fires burned 421 acres. The largest lightning fire burned 35 acres of meadows in the Walker fire in 1988. Humans have caused three meadow fires, which burned 54 acres. Meadows have been burned with 36 prescribed fires for a total of 433 acres. Over one-fourth of the acres (402) have burned once, while another 218 acres have burned twice or more. Fire return intervals are low in areas that were maintained by American Indians; in other areas the interval was more likely determined by the adjacent forest. Anderson (1993) reported anthropogenic fire regimes of from one to five years with a median of two years. Such short return intervals produce maximum departures of one for 911 acres of meadows ($FRID_{max}$ =1) and median departures of 35 ($FRID_{med}$ =35) for the same 911 acres. Most of the meadows show high departures from median fire return intervals. Fuel loads have increased and encroachment has altered much of this type.

Foothill Woodlands

The foothill woodlands zone includes foothill pine/live oak/chaparral woodland, foothill chaparral, and blue oak woodland vegetation types (UC Davis 1996e). This zone covers about 5% of the park at 1,700 to 6,000 feet elevation. Dominant tree species include California black oak, foothill pine, canyon live oak, interior live oak, and blue oak. Many of the vegetation types are better recognized by the dominant shrubs which include redbud, poison oak, various manzanitas, deerbrush, buckbrush, and mountain mahogany. Only 2% of the park's recorded lightning strikes hit the foothill zone (van Wagtendonk 1991). Even when made proportional to the size of the zone, only 8% of the strikes occur there—but when lightning fires occur they spread quickly and burn intensely.

Foothill pine/live oak/chaparral woodland

The foothill pine/live oak/chaparral woodland covers 6,985 acres in Yosemite and 372 acres in the El Portal Administrative Site. It is found on canyon sides and open rocky areas between 2,200 and 6,000 feet. The type covers a fairly contiguous area around Hetch Hetchy and Poopenaut Valleys. Dominant species include foothill pine, canyon live oak, interior live oak, Mariposa manzanita, deerbrush, buckbrush, and mountain mahogany. Little information about historical vegetation composition and patterns (UC Davis 1996e) exists so it is not possible to compare existing vegetation with historic vegetation condition or extent. This community has been invaded by cheat grass and other non-native annual grasses. Fuel loads can reach 22 tons per acre for foothill pine but are usually much lower (van Wagtendonk et al. 1998). In most cases, Fuel Model 5 depicts fire behavior in this type, but if brush over six feet tall is present Fuel Model 4 is a better fit.

Fires spread quickly and often torch and crown in trees and brush in the foothill pine/live oak/chaparral woodlands. Lightning is infrequent. Since 1930, 34 lightning fires have burned 8,514 acres in the park, and the A-Rock fire burned 41 acres of the type in the El Portal Administrative Site. Five human-caused fires have burned 1,424 acres in Yosemite, and three have burned 17 acres in El Portal. Only three prescribed burns have been conducted in these woodlands in the park covering 302 acres, while none have been ignited in El Portal. Over 90% of the foothill pine/live oak/chaparral woodland have burned during the past 70 years, leaving only 607 acres unburned. A total of 3,637 acres in the park have burned one time, 2,340 acres have burned two times, 312 acres have burned three times, and 90 acres have burned four times. In El Portal, 29 acres have burned once and 17 acres have burned twice. The small area burned in the Prescribed Natural Fire Zone in this type resulted in a fire rotation of 615 years, considerably longer than the fire return interval (van Wagtendonk 1994). McClaran and Bartolome (1989) determined that the minimum fire return interval for the woodlands was two years, the maximum 49 years, and the median eight years. Based on maximum intervals, 657 acres have missed one interval ($FRID_{max}$=1). Median departures ranged from 189 acres missing one interval ($FRID_{med}$ =1) to six acres having missed two ($FRID_{med}$= 2). It is assumed that the fuel load and stand structure are not significantly altered from the natural range of variability.

Foothill chaparral

Foothill chaparral covers 1,768 acres of the park on the north side of the Merced River Canyon between 1,600 and 5,000 feet in elevation and 17 acres in the El Portal Administrative Site near the park boundary. Manzanita, whitethorn, buckbrush, deerbrush, mountain mahogany, and interior live oak are all types of shrubs that occur in chaparral. This type grows on rocky dry sites on steep slopes with little soil and seldom has any understory vegetation. There is little information about historical vegetation composition and patterns for this type (UC Davis 1996e) and it is not possible to compare existing vegetation with historic vegetation. It is assumed that fire suppression has significantly altered typical species diversity and the age class mosaic that would have existed in this community under a natural fire regime. Fuel loads can reach 13 tons per acre but are usually much lower. In most cases, Fuel Model 5 depicts fire behavior in this type, but if brush over six feet tall is present, Fuel Model 4 is a better fit.

Between 1930 and 2000, seventeen lightning fires burned 520 acres of the foothill chaparral type in the park, and all 17 acres in El Portal were burned by the A-Rock fire. Other than the A-Rock Fire, the largest lightning fire to burn in this type in the park covered 43 acres during the Stanislaus Complex fires in 1987. Three human-caused fires in the park burned 25 acres, while six prescribed fires burned another 110 acres. In El Portal, the only human-caused fire was the Canyon fire that burned 12 acres in 1968. There have been no prescribed fires in foothill chaparral in El Portal. Although 1,243 acres of foothill pine/live oak/chaparral have not burned, 503 acres have burned once, and 39 acres have burned twice, including 12 acres in El Portal that were burned by the A-Rock Fire but which had previously burned in the Canyon Fire. Reported fire return intervals include a median interval of 30 years and a maximum interval of 60 years (SNEP 1996). Maximum departures of one interval occurred on 1,243 acres in the park ($FRID_{max}$ =1), while median departures of two intervals occurred on those same acres ($FRID_{med}$ =2). In El Portal, the type was within one fire return interval ($FRID_{max}$ =0). The natural mosaic of fuel load and patch ages may be moderately altered from the natural range of variability.

Blue oak woodland

Blue oak woodland covers 473 acres on the north side of the Merced River Canyon between 1,700 and 2,600 feet in elevation in the El Portal Administrative Site. Blue oak, interior live oak, foothill pine, California buckeye, and poison oak are the common woody species. A grassy understory is composed of non-native annual grasses and some native forbs. The grassy understory is the dominate ground cover between widely spaced shrubs and trees. Yellow star thistle, an invasive non-native, is also found in this type. There is little information about historical vegetation composition and patterns for this type (UC Davis 1996e) and we are unable to compare existing vegetation with a historic range of variability. Because non-native annual grasses have invaded the community, it can be assumed that the composition and structure of this grassland is significantly different than the native grassland. Fire suppression may have increased the density of shrub and trees in this area as well. Fuels are sparse and Fuel Model 1 best approximates fire behavior in this type.

Fires burn rapidly through the light fuels with flames from two to 10 feet in length. Since 1930, only two lightning fires have burned 315 acres of blue oak woodland; 311 acres were in the A-Rock fire alone. An additional 120 acres have been burned by three human-caused fires, and seven prescribed fires have burned 62 acres. A total of 208 acres have burned once, and re-burns have occurred twice on 135 acres and three times on 16 acres. The fire return intervals derived by McClaran and Bartolome (1989) for foothill pine/live oak/chaparral are used for blue oak woodland. All areas were within the maximum departures ($FRID_{max}$ =0), while the median fire return interval showed 322 acres missing one interval ($FRID_{med}$ =1), 21 acres missing two intervals ($FRID_{med}$ =2), and 114 acres missing four intervals ($FRID_{med}$ =4). The natural mosaic of fuel load and patch ages may be moderately altered from the natural range of variability.

Wetlands

This heading addresses areas that have attributes of wetlands, some of which do not sustain fire-dependent plant communities, but do nonetheless, require protection or consideration during fire management activities. Most meadows are considered wetlands, and thus, they are included in this discussion, as well as under Vegetation and Fire Ecology. Wetlands, as defined by the U.S. Fish and Wildlife Service and adopted by the National Park Service, are lands transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or the land is covered by shallow water. These ecosystems act to buffer hydrologic and erosional cycles, control and regulate biogeochemical cycles of nitrogen and other key nutrients, and create unique microclimates for animal species (Rundel and Stuner 1998). Wetland types in Yosemite include meadows, and wet areas along rivers, streams, lakes, and ponds. Wetlands greater than five acres were mapped through interpretation of aerial photography by the US Fish and Wildlife Service in 1995 as part of the National Wetlands Inventory (USFWS 1995). For the purposes of the *Final Yosemite Fire Management Plan/EIS* meadows and riparian areas were classified according to the surrounding vegetation type. Montane meadows are also addressed under Vegetation and Fire Ecology due to their ecological and cultural significance. Wetlands burn infrequently and are unlikely to play a role in fire ignition or maintenance. However, they are important in inhibiting fire spread. When wetlands do burn the fire usually spreads into them from adjacent vegetation.

Wildlife

Wildlife in Yosemite National Park is diverse and abundant, reflecting the wide range of Sierra Nevada habitats and vegetation types that are in relatively intact condition (table 3.4). Areas of concentrated human use in Yosemite and the El Portal Administrative Site have affected wildlife and their habitats, primarily by displacing animal populations that may have once been much more abundant. Fire suppression for over 70 years has significantly impacted habitat, also affecting wildlife populations.

Forest habitats and microclimates are in part created by forest structure. Structure is influenced by fire, or a lack of fire. For example, a stand replacement fire opens the forest and changes vegetation composition and thus, habitat, while fire suppression may allow the forest to fill with dense underbrush, again changing the habitat. Catastrophic events may replace large areas of old growth with plant communities not seen in those areas for many decades. Animals that use mature forests will likely leave the area and animals that favor more open vegetation will move in. Following a stand replacement fire, deerbrush ceanothus and greenleaf manzanita are early seral species that provide high quality forage for deer.

Wildlife populations respond to fire-caused habitat changes in many ways. If increased nutrients follow a fire, vegetation production will increase and it is likely that herbivores and other animals relying on the increase in nutrients will move into the area. If a change in forest structure creates favorable conditions for a prey species to increase substantially, the predators that rely on this prey will soon increase in numbers. Similarly, if the structure of a forest is deteriorating in condition, due to the absence of natural changes, certain wildlife species may move out because they cannot find the requirements to live. Many elements required by wildlife are increased or reduced by the presence or absence of fire.

The greatest impacts to wildlife and habitat from fire are those from fires exhibiting behavior that is unnatural to the fire regime for that area. Forest conditions conducive to large stand- replacement fires hold the biggest threat to wildlife because mature old growth forests can be converted to early seral stage communities more often and over a larger area then historically occurred. During and after these large, high-intensity fires there is significant displacement of wildlife. Yosemite National Park protects sizable tracts of old growth forest types that have disappeared from much of the Sierra Nevada because of logging. These protected habitats benefit California spotted owls (Verner et al. 1992), northern goshawk (Maurer 2000) and many other wildlife species that are dependent on them. Although logging no longer occurs in Yosemite, old growth habitats are at risk of catastrophic fire because of the long history of fire suppression in Yosemite and surrounding forests.

Habitat

For wildlife populations to be viable, resources and environmental conditions must be sufficient for animals to forage, hide, nest or den, and disperse. Distribution, types, and amounts of territory, shelter, and food must be sufficient for the needs of viable populations daily, seasonally, and annually. Habitat must be well distributed over a broad geographic area to allow breeding individuals to interact spatially and temporally within and among populations.

The burned area often responds beneficially within two or three growing seasons. The fire management program in Yosemite is a landscape level program applied to allow natural processes to maintain heterogeneity of the vegetation and wildlife in the park. Fire in its natural role would create and maintain a mosaic of different kinds and age structures of the native vegetation types. As of the year 2001, the habitat associated with the lower montane forests is that most impacted by fire exclusion prior to 1970.

Fire exclusion or altered fire regimes have two major effects on wildlife habitat that cause significant population shifts. As fire is excluded, there becomes a greater continuity and abundance of late-successional plants. This reduces open space and creates landscapes with extensive ladder fuels and nearly continuous thickets of dense tree regeneration. The results of this are not clearly known but it can be postulated that the composition of wildlife that once occupied these areas has likely been shifting with this increased biomass.

Mammals

Approximately 85 native mammal species in six families inhabit Yosemite. Of the insectivore family, five shrews and one mole live here. Seventeen species of bats inhabit the forests and cliffs of Yosemite, nine are either California species of special concern or federal species of concern. Many of these bat species depend on riparian and meadow habitats for foraging and large trees or snags for roosting. Carnivores include black bears, bobcats, coyotes, raccoons, weasels, gray foxes, mountain lions, and ringtails. Six species of squirrels, eight species of chipmunks, eight species of mice, and other species of rodents, including wood rats, voles, gophers, and porcupines inhabit the park and El Portal. Yosemite's largest mammal, the grizzly bear, was extirpated from the region and from the state in the 1920s. There are two native species of hoofed mammals: the Sierra Nevada bighorn sheep and mule deer. Other mammal species that occur but are rarely seen are the fisher, wolverine, and Sierra Nevada red fox.

Birds

Yosemite's wide range of elevations and habitats support a diversity of bird species. Approximately 150 species regularly occur in the park, and about 80% of these are known or suspected to breed there. Members of most of the bird species begin to migrate to lower elevations or latitudes in the late summer and fall. For example, of the 84 species that nest in Yosemite Valley, 54% are rare or absent in winter. Noticeable population declines have been detected in numerous bird species in the Sierra Nevada, including Yosemite. Possible causes for these declines include grazing, logging, fire suppression, development, recreational use, pesticides, habitat destruction on wintering grounds, and large-scale climate changes.

Table III-4
Wildlife Species Inhabiting Vegetation Types

Vegetation Zone	Vegetation Types	Some Species Likely to Occur
Subalpine Forests	Whitebark pine/mountain hemlock forest	Golden eagle, Clark's Nutcracker, golden-mantled ground squirrel, alpine chipmunk, long-tailed vole, yellow-bellied marmot, porcupine, coyote, ermine, black bear.
	Lodgepole pine forest	Sagebrush lizard, western terrestrial garter snake, northern goshawk, red-tailed hawk, white-throated swift, Williamson's sapsucker, dusky flycatcher, mountain chickadee, pine siskin, deer mouse, long-tailed vole, coyote, ermine, long-tailed weasel, American badger, black bear.
Upper Montane Forests	Red fir forest	Western terrestrial garter snake, red-tailed hawk, golden eagle, great gray owl, olive-sided flycatcher, red-breasted sapsucker, golden mantled ground squirrel, deer mouse, bushy-tailed woodrat, coyote, long-tailed weasel, black bear.
	Western white pine/Jeffery pine forest	Sagebrush lizard, northern goshawk, red-tailed hawk, golden eagle, mountain quail, Lewis' woodpecker, northern flicker, olive-sided flycatcher, western wood-pewee, Steller's jay, lodgepole chipmunk, golden-mantled ground squirrel, striped skunk, black bear, gray fox, fisher, bobcat, mule deer, black bear.
	Montane chaparral	Gilbert's skink, southern alligator lizard, red-tailed hawk, California quail, mountain quail, bushtit, barn swallow, ruby-crowned kinglet, brush rabbit, California ground squirrel, Botta's pocket gopher, coyote, California pocket mouse, badger, striped skunk, black bear.

Vegetation Zone	Vegetation Types	Some Species Likely to Occur
Lower Montane Forests	Giant sequoia/mixed-coniferous forest	Western fence lizard, western rattlesnake, sharp-shinned hawk, American kestrel, acorn woodpecker, violet-green swallow, barn swallow, yellow warbler, chipping sparrow, California ground squirrel, mountain pocket gopher, coyote, badger, striped skunk, black bear.
	White fir/mixed-conifer forest	Western fence lizard, northern alligator lizard, sharp-shinned hawk, great horned owl, Steller's jay, common raven, fox sparrow, dark-eyed junco, big brown bat, Botta's pocket gopher, deer mouse, brush mouse, coyote, ermine, gray fox, striped skunk, badger, black bear.
	Ponderosa pine/mixed-conifer forest Ponderosa pine/bear clover forest	Western fence lizard, northern alligator lizard, red-tailed hawk, American kestrel, flammulated owl, western wood-pewee, Hammond's flycatcher, ruby-crowned kinglet, big brown bat, long-tailed vole, California ground squirrel, deer mouse, coyote, gray fox, ermine, striped skunk, black bear.
	California black oak	Western fence lizard, northern alligator lizard, sharp-shinned hawk, Cooper's hawk, band-tailed pigeon, red-breasted sapsucker, acorn woodpecker, big brown bat, brush rabbit, coyote, gray fox, long-tailed weasel, striped skunk, black bear.
	Canyon live oak forest	Western fence lizard, Western rattlesnake, scrub jay, California towhee, Hutton's vireo, oak titmouse, acorn woodpecker, western harvest mouse, western gray squirrel, California ground squirrel, ringtail, coyote, black bear, striped skunk.
Meadow	Dry montane meadow	California newt, California mountain kingsnake, western aquatic garter snake, Pacific tree frog, mallard, great blue heron, common snipe, great gray owl, northern rough-winged swallow, mountain bluebird, California meadow vole, montane vole, western mastiff bat, yellow-bellied marmot, mountain beaver, black bear, ermine.
Foothill Woodlands	Foothill pine/live oak/chaparral woodland Foothill chaparral Blue oak woodland	Northern alligator lizard, red-tailed hawk, American kestrel, great horned owl, Anna's hummingbird, red-breasted sapsucker, scrub jay, western bluebird, wrentit, big brown bat, black tailed jackrabbit, California ground squirrel, deer mouse, brush mouse, coyote, gray fox, long-tailed weasel, striped skunk, black bear.
Barren	Barren (includes bare rock and water)	Mount Lyell salamander, mountain yellow-legged frog, rosy finch, American pipit, rock wren, raven, Belding's ground squirrel, American pika, yellow-bellied marmot.

Reptiles and Amphibians

Compared to most mountain regions of the west, Yosemite has a large number of native reptile and amphibian species: 14 snakes (one poisonous), 7 lizards, 1 turtle, 2 toads, 1 tree frog, 3 true frogs, and 5 salamanders (including newt and ensatina). As in the rest of the Sierra Nevada, amphibians in Yosemite have suffered population declines (Drost and Fellers 1996). At higher elevations, mountain yellow-legged frogs and Yosemite toads are still present; however, they are severely reduced in population size and range. Research continues to identify the causes of decline in Sierra Nevada amphibians. Possible causes include habitat destruction, non-native fish and frogs, pesticides, and diseases. Two of the species of true frogs once found in Yosemite are now apparently extirpated: foothill yellow-legged frog and California red-legged frog. Possible factors in their disappearance include a reduction in perennial ponds and wetlands and predation by non-native bullfrogs.

Fish, including Non-Native Species

Most fish inhabiting Yosemite's lakes and streams have been introduced. Prior to trout stocking for sport fishing, native fish were limited in both range and number of species.

The last period of glaciation eliminated all fish from the high country and the high waterfalls prevented repopulation by upstream migration so that only the lower systems of the Tuolumne and Merced Rivers were populated with native fish. Rainbow trout and Sacramento sucker were abundant; less common were the Sacramento pike-minnow, hardhead, California roach, and riffle sculpin.

Brown trout and non-native strains of rainbow trout have been introduced to lower reaches of the Merced and Tuolumne Rivers, which has altered the aquatic ecosystems. The widespread introduction of brown, rainbow, and brook trout in higher-elevation lakes and streams, all of which were naturally fishless, has likely altered those ecosystems as well. Such introductions of fish are suspected of being the primary factor in declines of native amphibian species in the Sierra Nevada (Drost and Fellers 1994; 1996).

Because of severe climatic conditions, low nutrient availability associated with snowmelt over granitic watersheds, and a lack of spawning habitat, fish introduced in many of Yosemite's lakes have not survived. Fishery surveys conducted in the mid-1970s found 62 lakes with self-supporting fish populations, and 195 with little or no natural reproduction. Approximately 550 miles of streams in Yosemite National Park are thought to support fish (NPS 1977).

After recognizing that non-native species were causing damage to aquatic ecosystems, in 1978 the park implemented a policy that by 1991 had ended almost 100 years of stocking lakes with non-native fish in Yosemite. Human activity has undoubtedly altered fish populations in the Merced River in the Yosemite Valley section where rafting, trampling, camping along the streams, and tree removal was allowed for many years. Non-native brown trout now outnumber rainbow trout in many stretches of the Merced River, and introductions of non-native rainbow trout have altered the genetics of Yosemite Valley's native strain.

Non-Native Wildlife Species

Besides the several species of introduced trout, non-native wildlife in Yosemite National Park includes white-tailed ptarmigan, wild turkey, brown-headed cowbird, European starling, house sparrow, and bullfrog. Feral pigs have recently been sighted near the park and could establish territories in the park.

The full impact of bullfrogs on native species in the park is unknown, but studies in other areas of California have concluded that bullfrogs prey on a wide variety of animals, including insects, fish, other amphibians, birds, reptiles, and small mammals. Recent observations suggest that they currently occupy standing and slow-moving water throughout the Yosemite Valley.

Brown-headed cowbird populations in the Sierra Nevada have increased (Verner and Ritter 1983) and now threaten native bird species. Cowbirds lay their eggs in the nests of other birds, usually songbirds. This parasitism can have a devastating effect on the populations of some native songbird species. Cowbirds have been implicated as a factor in the disappearance of willow flycatchers from Yosemite Valley. Currently, brown-headed cowbirds are common in Yosemite and can be found in large numbers at the park's stables, campgrounds, and residential areas.

Wild turkeys were introduced widely in California by state authorities, and have moved into Yosemite along its western boundary. The impact of this species on park ecosystems is unknown, but likely includes predation of small animals, competition with native species for food, destruction of native plants and reduction of their seeding rates (especially in oaks), soil and forest litter disturbance, and support of unnaturally high predator populations.

White-tailed ptarmigan were introduced as a game species to high elevation areas east of Yosemite, and they have become widespread in the park's alpine habitats. The impact of ptarmigan has not been determined, but their herbivory likely affects native plants that have a very low rate of growth and productivity.

The European starling and house sparrow are two non-native species found in El Portal that affect native bird species through competition for nest cavities, a limited resource. Both species are known to aggressively evict native bird species from occupied cavities. The existing development in El Portal has likely increased the abundance of both species by providing additional nesting sites and food sources.

Special-Status Species

Some species of plants and animals have undergone local, state, or national declines, which has raised concerns about their possible extinction if they are not protected. As a result, the USFWS and California Department of Fish and Game (CDFG) have established a classification system that reflects the urgency of species' status and the need for monitoring, protection, and recovery. Collectively, species in these categories are referred to in this document as "special-status species." In addition, the park has a classification system that reflects the prevalence of species within the park. These are "park rare" plants and are tracked by the park.

The Federal Endangered Species Act of 1973, as amended, requires federal agencies to consult with the USFWS before taking actions that (1) could jeopardize the continued existence of any federally listed plant or animal species (e.g., listed as threatened or endangered) or species proposed for listing, or (2) could result in the destruction or adverse modification of critical or proposed critical habitat. The first step in the consultation process is to obtain a list of protected species from the USFWS.

The *Council of Environmental Quality Regulations for Implementing the National Environmental Policy Act* (Section 1508.27) requires considering whether an action may violate federal, state, or local law or requirements imposed for the protection of the environment. For this reason, species listed under the California Endangered Species Act (i.e., those considered endangered or threatened) by the CDFG are included in this analysis. Those species proposed for listing in either of the two categories are also included.

The various federal and state categories for special-status species are defined as:

Federal endangered: Any species that is in danger of extinction throughout all or a significant portion of its national range.

Federal threatened: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its national range.

California endangered: Any species that is in danger of extinction throughout all or a significant portion of its range in the state.

California threatened: Any species that is likely to become an endangered species with the foreseeable future throughout all or a significant portion of its state range.

California rare (plants only): A native plant that, although not currently threatened with extinction, is present in small numbers throughout its range, such that it may become endangered if its present environment worsens.

Special-Status Plants

A total of four plant species known to occur in Yosemite National Park and/or the El Portal Administrative Site have been listed as "rare" by the State of California: Yosemite onion, Tompkin's sedge, Congdon's wooly-sunflower, and Congdon's lewisia (Table 3.5). These species are considered restricted and limited throughout all or a significant portion of their range, and may represent disjunct populations at the extremes of their range. The *Natural Resources Management Guidelines* (NPS-77) state that the identification of a plant as a rare species warrants heightened management concern. In the study area, these four plants are at lower elevations in the Lower Montane and Foothills Woodlands vegetation zones—mainly in and near El Portal.

There are six federal Species of Concern (not listed but tracked by the USFWS). In addition, 103 'park rare' species have limited distribution in Yosemite but are not necessarily limited in their range. These are tracked by the park although they are not listed as endangered or threatened. They are not included for analysis in this section.

Table III-5
California State Rare Plants Known to Occur in Yosemite National Park or the El Portal Administrative Site

Common Name ***Scientific Name***	**Vegetation Zone [a]: Habitat Type/Occurrence**
Yosemite Onion *Allium yosemitense*	LM, FW: Confined to open metamorphic slabs, talus slopes, and scree. Restricted to the Merced River watershed.
Tompkin's sedge *Carex tompkinsii*	LM, FW: Limited to foothill oak woodland and chaparral areas and along lower talus slopes. Found sporadically from Arch Rock to El Portal in the Merced River canyon.
Congdon's woolly-sunflower *Eriophyllum congdonii*	LM, FW: Restricted to dry, mostly south-facing metamorphic and metasedimentary outcrops. Occurs on dry ridges on metamorphic rocks, scree, and talus.
Congdon's lewisia *Lewisia congdonii*	LM, FW: Grows on moist, exposed metamorphic rock faces and slopes. Occurs in chaparral and mixed-conifer forest on north-facing slopes in shade.

a LM=Lower Montane, FW=Foothills Woodland.

Special-Status Species – Wildlife

Table 3.6 presents both state and federal listed threatened or endangered animal species (valley elderberry longhorn beetle, limestone salamander, California red-legged frog, bald eagle, American peregrine falcon, great gray owl, willow flycatcher, Sierra Nevada red fox, California wolverine, and Sierra Nevada bighorn sheep) and four species that are proposed for listing (Yosemite toad, mountain yellow-legged frog, California spotted owl, and Pacific fisher). These species are known to be or could be present in Yosemite National Park or the El Portal Administrative Site and therefore could be affected directly or indirectly by the action alternatives. A Biological Opinion (Appendix 9) has been prepared, in accordance with Section 7 of the Endangered Species Act.

Table III-6
Special Status Wildlife Species

Special-Status Species – Wildlife				
Species	**Status [a]**			**Vegetation Zone [b]: Habitat Type/Occurrence**
	USFWS	**State**	**Park**	
INVERTEBRATES				
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	FT			FW: Found in conjunction with its host plant, the elderberry (*Sambucus* spp.), below 3,000 feet in elevation.

Special-Status Species – Wildlife				
Species	**Status[a]**			**Vegetation Zone[b]: Habitat Type/Occurrence**
	USFWS	**State**	**Park**	
REPTILES AND AMPHIBIANS				
Limestone salamander *Hydromantes brunus*	FSC	CT		FW: Very limited distribution along Merced River and its tributaries between elevations of 800 and 2,500 feet, usually in association with limestone outcrops. El Portal lies within elevational range, but not recorded there or elsewhere in park.
Yosemite toad (**Proposed**) *Bufo canorus*	FSC	CSC		SA, UM, BA: Restricted to areas of wet meadows in central Sierra Nevada between elevations of 6,400 and 11,300 feet.
California red-legged frog *Rana aurora draytonii*	FT	CSC		LM, CO, ME: Found in quiet pools in permanent streams in mixed-conifer zones and foothills. Prefers riparian deciduous habitat. Many park museum specimens from one lake (6,000 feet elevation). Once found in Yosemite Valley, but now apparently extinct due to loss of habitat and predation by bullfrogs and other species.
a Status: FT=Federal Threatened, FE=Federal Endangered, FSC=Federal Species of Concern, FD=Federal De-listed, CE=California Endangered, CT=California Threatened, CSC=California Species of Concern. b SA=Subalpine Forest, UM=Upper Montane, LM=Lower Montane, FW=Foothills Woodland, ME=Meadow, BA=Barren.				
Mountain yellow-legged frog *Rana muscosa* (**Proposed**)	FSC	CSC		SA, UM, LM, BA: A species of mountain habitats, occurring between elevations of 4,500 to over 12,000 feet; found in streams, lakes, and ponds in a variety of vegetation types.
BIRDS				
Bald eagle *Haliaeetus leucocephalus*	FT	CE		LM, CO, ME, BA: Forages over river, streams, and lakes. Primarily eats fish, also carrion, water birds, and small mammals. Transient in the park. No nesting in the park.
American peregrine falcon *Falco peregrinus anatum*	FD	CE		LM, CO, ME, BA: Usually nest on high cliffs near water and searches for prey along cliffs and over surrounding habitats. Four known active nest sites in Yosemite. Species has shown recovery, but numbers may continue to be affected by pesticide contamination.
California spotted owl *Strix occidentalis occidentalis* (**Proposed**)	FSC	CSC		UM, LM, FW: Breeds in oak and ponderosa pine forests upslope to lower-elevation red fir forests (up to elevations of 7,600 feet), with mixed-conifer the optimum type. Presence of California black oak in the forest canopy also enhances habitat suitability. Likely cause for decline is habitat destruction and fragmentation from logging and development. Severe wildland fire in mixed-conifer forests may represent the greatest threat to existing spotted owl habitat in Yosemite.
Great gray owl *Strix nebulosa*		CE		UM, LM, CO: Entire California population of this species is restricted to the Yosemite region, where it reaches southernmost extent of its North American range. Breeds in mixed-conifer/red fir forests bordering meadows. Winters in mixed-conifer down to blue oak woodlands. Research suggests that human disturbance could affect foraging success of this species, which may explain its absence from the Valley.
Willow flycatcher *Empidonax trailii*	FSC *(ssp. Brewsteri)*	CE		LM, FW, ME: Breeds in mountain meadows. and riparian areas from 2,000 to 8,000 feet elevation in the Sierra Nevada, with lush growth of shrubby willows. Has disappeared from much of its range, due to habitat destruction and parasitism from brown-headed cowbirds.

Special-Status Species – Wildlife				
Species	Status[a]			Vegetation Zone[b]: Habitat Type/Occurrence
	USFWS	State	Park	
a Status: FT=Federal Threatened, FE=Federal Endangered, FSC=Federal Species of Concern, FD=Federal De-listed, CE=California Endangered, CT=California Threatened, CSC=California Species of Concern. b SA=Subalpine Forest, UM=Upper Montane, LM=Lower Montane, FW=Foothills Woodland, ME=Meadow, BA=Barren.				
MAMMALS				
Sierra Nevada red fox *Vulpes vulpes necator*	FSC	CT		SA, UM, LM, BA, ME: Primarily found in red fir, lodgepole pine, subalpine forests, and alpine Sierra. Found mostly above 7,000 feet and rarely below 5,000 feet elevation. Reports for Yosemite Valley and Foresta, but these sightings could have been of eastern red fox, a non-native species that is present on the west slope of the Sierra Nevada.
California wolverine *Gulo gulo luteus*	FSC	CT		SA, UM, ME, BA: Found in a wide variety of mountain habitats. Needs water, caves, logs, or other cover for denning. No wolverine has been recorded in California since the 1970s.
Pacific fisher **(Proposed**) *Martes pennanti pacifica*	FSC	CSC		UM, LM: Occurs in conifer forests and deciduous-riparian habitats with a high canopy closure, mostly above 6,000 feet elevations. Carnivorous, but may also eat fruit and fungi. Densities in the central Sierra Nevada appear to be very low, for unknown reasons; higher densities in both the northern and southern Sierra Nevada. Fishers have been seen within the last 10 years near Henness Ridge and Crane Flat.
Sierra Nevada bighorn sheep *Ovis canadensis sierrae*	FE	CE		BA: High-elevation species that was reintroduced to the park in 1986. Population numbers have fluctuated between a high of 85+ animals in 1991 to less than 20 today.
a Status: FT=Federal Threatened, FE=Federal Endangered, FSC=Federal Species of Concern, FD=Federal De-listed, CE=California Endangered, CT=California Threatened, CSC=California Species of Concern. b SA=Subalpine Forest, UM=Upper Montane, LM=Lower Montane, FW=Foothills Woodland, ME=Meadow, BA=Barren.				

Physical Environment

Geologic Overview

The geologic story of the Sierra Nevada can be considered in two parts: (1) the deposition and formation of sedimentary and volcanic rock over a period of hundreds of millions of years and the intrusion of granitic rocks, and (2) the uplift, erosion, and glaciation of the environment to form today's landscape (Huber 1989).

At its foundation, the Sierra Nevada is an enormous deposit of granitic rock (UC Davis 1996a). About 200 million years ago, as the granitic rocks were formed, heated, and melted, they slowly migrated toward the surface of the earth. The surface of the earth at the time was composed of massive layers of sedimentary rock deposited by ancient seas and volcanic rock that was deposited by ancient volcanic eruptions. As the granitic plutons rose, they altered some of the sedimentary and volcanic rock and created metamorphic rock.

Between 65 and 100 million years ago, magma formation slowed and a long period of erosion began in the Sierra Nevada. About 25 to 15 million years ago, mountain building activity reactivated, uplifting the Sierra Nevada to form its relatively gentle western slopes and the more dramatic, steep eastern slopes. A combination of uplift and tilt is the underlying geologic process that created the range as we see it today (Huber 1989).

As the world grew colder between two and three million years ago, the Sierra Nevada had risen high enough for glaciers and mountain ice fields to form at the higher alpine elevations. At least three major glacial periods occurred during the ice age in the Sierra Nevada. The down slope movement of the ice masses cut and sculpted valleys, cirques, and other glacially formed landforms throughout the Yosemite region and the Sierra Nevada. The last glaciation event began as late as 60,000 years ago. In the Yosemite area, this glaciation pushed fingers of ice into the major drainages on the west slopes, until it reached the maximum extent about 20,000 years ago, near Bridalveil Meadow in Yosemite Valley.

Climate

The climate of Yosemite is Mediterranean. Precipitation amounts vary from 36 inches (915 mm) at 4000 feet (1,200 m) to 50 inches (1,200 mm) at 8,600 feet (2,600 m). Most of the precipitation falls as snow between October and April. From May through September, precipitation is infrequent.

Mean daily temperatures range from 25 to 53 degrees Fahrenheit at Tuolumne Meadows at 8,600 feet (2,600 m). At South Entrance Station (elevation 6,192 feet) mean daily temperature ranges from 36 to 67 degrees Fahrenheit. At the lower elevations, below 5,000 feet, temperatures are hotter; mean daily high temperature at Yosemite Valley (elevation 3,966 feet) varies from 46 to 90 degrees Fahrenheit. Frequent summer thunderstorms, along with snow that can persist into July, moderate the hot, dry summers, especially above 8,000 feet. The combination of dry vegetation, low relative humidity, and thunderstorms results in frequent lightning caused fires as well (NPS 1990).

Soils

More than 50 soil types exist within the park; general or local variations depend on glacial history and the ongoing influences of weathering and stream erosion and deposition. Topography influences surface water runoff, groundwater, distribution of stony soils, and the separation of alluvial soils (Zinke and Alexander 1963). Local variations also result from differences in microclimates due to aspect and major vegetation types.

Soils of the Yosemite region are primarily derived from underlying granitic bedrock and are of a similar chemical and mineralogical composition. Except for meadow soils, most soils at high elevations were developed from glacial material (glacial soils) or developed in place from bedrock (residual soils). Extensive areas above 6,000 feet are covered by glacial moraine material, a mixture of fine sand, glacial flour, pebbles, cobbles, and boulders of various sizes. *Alluvial* soils, along streams, tend to have sorted horizons (layers) of sandy material. Colluvial soils along the edges of the Valley in areas where landslides and rockslides have occurred are composed of variously sized particles and rocks and have high rates of infiltration and permeability.

Organic content within the upper soil profile varies with the local influences of moisture and drainage. Thick sedges and grasses have contributed to the organic content of soils near ponds, lakes, and streams. Coniferous forest soils have a relatively high organic content and are relatively acidic. Soils lacking organic accumulations are frequently a result of granitic weathering, consist largely of sand, and support only scattered plants tolerant to drought-like conditions.

Certain soil types have been identified in Yosemite as highly valued resources (NPS 2000c). Highly valued resource soils are found in or adjacent to meadows and riparian areas, hydric soils, and soils associated with lateral or terminal moraines. The Leidig fine sandy loam found in and around Leidig Meadow is an example of a highly valued resource soil.

Hydric soils are legally protected because they form in wetlands, which are protected by federal law. Hydric soils are found primarily in the river valleys of the Merced River and Tenaya Creek and in low meadows.

Interaction of Fire and Soil

All fire, whether natural or human-caused, changes the cycling of nutrients and the biotic and physical characteristics of soils. The magnitude and longevity of these effects depend on many factors including fire regime, severity of a particular fire, vegetation and soil type, topography, season of burning, and pre- and post-fire weather conditions. Effects can also be indirect, through changes in soil biota and changes in erosional rates. Sites that historically had frequent fires are generally better adapted to the reintroduction of fire and repeated burning.

Fire causes soil nutrients to change in form, composition, distribution, and amount. These changes are from the release of elements during combustion of fuel and organic matter. The *volatilization*, or release, is temperature dependant. Nitrogen, and to a lesser extent sulfur and phosphorus, are most readily lost. Other nutrients are generally lost as ash via convection or through leaching. Burning can decrease total nitrogen availability at a site while increasing nitrogen available for plant growth. Following prescribed burns in Giant Forest in Sequoia National Park, inorganic soil ammonium-nitrogen (NH_4^+-N) levels increased from 1.90 mg/k of soil under sequoias and 1.66 mg/k of soil under sugar pines to 68.63 mg/k and 62.71 mg/k respectively immediately after the fire (Haase and Sackett 1998). By five years, NH_4^+-N had returned to pre-burn levels (1.54 and 1.60 mg/k soil respectively) and by seven years had dropped below pre-burn levels (1.12 and 1.52 mg/k soil respectively). Changes in nitrate-nitrogen (NH_4^--N) were similar except peaks occurred two years after the burn. Other nutrients (CA, Mg, K, and SO_4) also increased with SO_4 increasing by an order of magnitude (Chorover et al. 1994; Williams and Melack 1997).

Biotic soil communities are complex and still poorly understood, particularly in relation to fire effects. Fire can influence soil biota directly by killing or injuring organisms, or indirectly by altering properties of the above- and below-ground soil environment. Burning generally results in declines in soil invertebrates and fungi while microorganisms such as bacteria increase in abundance. Changes in aboveground biotic communities due to changes in the fire regime may also impact soils and interact with soil nutrient status. For example, nitrogen-fixing plants are suppressed in some fire-excluded forests (Newland and DeLuca 2000). Additionally, the effects of fire on cryptogramic crusts, (important nitrogen fixers in some ecosystems) has not been explored.

Changes in physical characteristics of soil following fire are a result of complex interactions among geomorphic processes, climate, vegetation, and landforms. Fire can affect changes in organic horizons, water repellency, infiltration capacity, porosity, structure, temperature, hydrologic properties, and, most importantly, erosional processes and sedimentation rates. Fire generally increases the potential for erosion by removing vegetation and exposing mineral soil and by altering organic matter and the physical properties of soil. Generally, the more severe a fire, the greater its effects will be. These effects are further affected by soil erodibility, slope steepness, and the timing, intensity, and amount of precipitation. The magnitude of fire's impact on soils is highly dependent on the situation and the physical and biotic properties of the area. Recent studies show that the deliberate use of prescribed fire may dramatically reduce erosion potential from wildland fires. In one study, erosion and sediment from a high intensity wildfire event was ten times higher than that measured off a low intensity prescribed burn (Wohlegmuth et al. 1999).

In most park ecosystems prior to Euro-American settlement, fire affected both the soils and geomorphic processes. The alteration of the natural fire regime by nearly a century of human intervention can be considered a significant alteration of and stressor to soil properties and processes. Understanding changes from fire suppression and restoration of fire is important. For example, there is the potential for increased erosion in areas of chaparral vegetation due to the complete removal of most aboveground biomass by fire. This differs from Sierran mixed-conifer forest where overstory vegetation is generally maintained after fire.

Because of the landscape scale of some effects of fire, they could have significant impacts both inside and outside the park. Impacts and processes within the park may be considered ecologically natural, while the same process may produce effects outside the park that are considered undesirable. For example, it would be important to understand whether there are significant erosional and sedimentation risks associated with certain types of fire because of downstream structures, such as dams, flumes, and hydroelectric generation plants, on the Tuolumne and Merced Rivers.

Water Resources and Watersheds

Within the boundaries of Yosemite flow the headwaters and significant stream reaches of the Tuolumne and Merced Rivers, both of which are tributaries of the San Joaquin River basin. The park also contains approximately 3,200 lakes (greater than 100 square meters), two reservoirs, and 1,700 miles of streams, all of which help form these two large watersheds.

The Tuolumne and Merced River watersheds originate along the ragged crest of the Sierra Nevada. Waters tumble down rocky, sparsely vegetated mountainsides; course through forests underlain with granitic bedrock and strewn with boulders; and flow through nearly flat, glacially-carved valleys on their paths to the Central Valley. Areas of small lakes and meadows, typically underlain with thin, granitic soils, can be quite extensive despite the rugged landscape. Above 9,600 feet, alpine and subalpine zones have little vegetation and low soil permeability. From 8,000 to 9,600 feet, the upper montane zone has limited ability to hold soil moisture. Lower montane forests grow on thin to moderate depth soils from 4,000 to 7,000 feet.

The Tuolumne River drains the entire northern portion of the park, an area of approximately 428,115 acres (669 square miles). It flows into Hetch Hetchy reservoir, a major water supply for the City and County of San Francisco, before it leaves the park. The main stem and the South Fork of the Merced River drain the southern portion of the park, approximately 319,840 acres (499 square miles). Below Yosemite Valley, the main stem flows through the El Portal Administrative Site.

Regional Watershed Characteristics

Merced River (Main Stem) Watershed. The main stem of the Merced River watershed drains 250,000 acres (391 square miles) of the park. Principal tributaries of the Merced River include the Merced Peak, Lyell, Triple Peak, and Red Peak Forks, as well as Echo, Sunrise, Illilouette, Tenaya, Yosemite, Bridalveil, Cascade, Grouse, Avalanche, Indian, and Crane Creeks. For the purpose of this discussion, the main stem of the Merced River is divided into three hydrologic segments: the upper Merced River, Yosemite Valley, and the

Merced River gorge (which includes the El Portal Administrative Site). This division is based upon the unique watershed characteristics of the three river areas.

Upper Merced River. The upper Merced River watershed encompasses approximately 114,840 acres (181.9 square miles) above Happy Isles in upper Yosemite Valley. Elevations range from 4,000 feet to over 13,000 feet at Mt. Lyell. Located within the watershed are the sub-basins of Merced Peak, Lyell, Triple Peak, and Red Peak Forks; Echo, Sunrise, and Illilouette Creeks; and over 1,000 lakes and ponds (Williamson et al. 1996a). The upper Merced River descends from its headwaters through a glacially carved canyon at a gradient of about 8,000 feet over 24 miles (USGS 1992). The average daily discharge rate measured at the Happy Isles gauging station is approximately 355 cfs (USGS 1998).

Yosemite Valley. The Yosemite Valley watershed includes Yosemite Valley and its tributary areas. Tributaries include Tenaya, Yosemite, Sentinel, Ribbon, and Bridalveil Creeks. Above Pohono Bridge, the Merced River basin encompasses 205,000 acres (321 square miles) (USGS 1999). Historic discharge in the river, measured at the Pohono Bridge gauging station, has ranged from a high of about 25,000 cfs to a low of less than 10 cfs. During the last glaciation, a glacier extended to below Bridalveil Fall—leaving the nearly flat valley floor through which the river flows in a shallow channel approximately 100 to 300 feet wide in most places. The bed and banks of the channel are composed of smaller sediments and cobbles, material created and deposited by the succession of glaciers that helped form the Valley. The river alters its course periodically by eroding and re-depositing this loose material.

Merced River Gorge. As the river exits Yosemite Valley, it cascades at an average gradient of approximately 70 feet per mile through the narrow, steep-sided Merced River gorge. The Merced River gorge watershed includes the area from Pohono Bridge through the El Portal Administrative Site. At the western end of Yosemite Valley, where the river transitions into the steep river gorge, Cascades Diversion Dam collects suspended sediments and bedload discharging from the Valley. Tributaries along the gorge include Cascade, Tamarack, Wildcat, Grouse, Avalanche, Indian, Crane, and Moss Creeks. The riverbed and banks are largely composed of boulders and cobbles, ranging in size from a few inches to several yards in diameter. Much of the riverbank has been developed and hardened for road and facility protection. Because of the steep gradient and development, the river channel usually only shifts during periods of large floods. There are no flow gauges in the gorge.

South Fork Watershed. The headwaters of the South Fork originate near Triple Divide Peak at an elevation of approximately 10,500 feet. The South Fork flows westward over granitic bedrock to Wawona and then flows northwest over an area underlain by sedimentary rocks at a 3,500-foot elevation (USGS 1995a) and into the Merced River downstream from El Portal. Chilnualna, Big, Alder, and Bishop Creeks are major tributaries to the South Fork. The watershed area of the South Fork at Wawona is approximately 63,000 acres (98 square miles) and about 154,000 acres (approximately 70,000 acres within the park) by the time it reaches the main stem. Upstream from Wawona, tributaries enter the steep-walled glacial gorge of the South Fork from the north and south. In the Wawona area, the river meanders through a large floodplain meadow (part of a deep alluvial valley), building substantial gravel bars within the channel. The average annual flow at its confluence with the Merced River is 356 cfs (USGS 1989). Between 1958 and 1968, upstream of the Big Creek confluence, the average annual flow was 174 cfs.

Tuolumne River Watershed. The Tuolumne River originates in the peaks above Tuolumne Meadows and is the major drainage system for the northern part of Yosemite. The river and its tributaries drain in excess of 669 square miles of the park. The Tuolumne has two principal sources: the Dana Fork, which drains the west-facing slopes of the 13,053-feet-high Mount Dana, and the Lyell Fork, which begins at the base of the glacier on Mount Lyell at an elevation of 13,114 feet. Confluence of the two forks occurs at the eastern end of Tuolumne Meadows. The Tuolumne River continues through Tuolumne Meadows and the associated park developments at an elevation of 8,600 feet. It then cascades on its westward decent through the Grand Canyon of the Tuolumne, and enters the eastern end of Hetch Hetchy Reservoir, still within the park, at an elevation of about 4,000 feet. Return, Paiute, Rancheria, and Falls Creeks enter the Tuolumne River upstream of the reservoir and along the reservoir's shores. At O'Shaughnessy Dam, which impounds the Tuolumne, water is diverted through Canyon Tunnel to the Kirkwood Powerhouse. Water that is not diverted continues downstream in the Tuolumne River channel, reaching the park boundary about six miles downstream, near the Mather Ranger Station.

Hetch Hetchy and Lake Eleanor Reservoirs. These two reservoirs are in Yosemite, within the Tuolumne watershed and are part of a massive system of water and power production operated by the City and County of San Francisco. Hetch Hetchy is on the main stem of the Tuolumne River and Lake Eleanor is on Eleanor Creek, upstream of its confluence with Cherry Creek. Cherry Creek joins the Tuolumne River downstream of the park's western boundary. Hetch Hetchy is dammed by the 430-foot-tall O'Shaughnessy Dam and has a storage capacity of 360,360 acre-feet. It is the primary water source for about 2.5 million residents of the San Francisco Bay area. Lake Eleanor's maximum volume of 27,100 acre-feet was created by building the 70-foot-tall Lake Eleanor Dam in 1918.

Middle Tuolumne River. The Middle Tuolumne River drains a small portion of the park's extreme western edge, south of Hetch Hetchy Reservoir and northwest of the Tioga Road. The headwaters are between 7,000 and 8,000 feet in elevation. Cottonwood Creek is a major tributary. The Middle Tuolumne River exits the park at an elevation of 5,000 feet and joins the South Fork Tuolumne River downstream of the park.

South Fork Tuolumne River. The South Fork Tuolumne River drains a small portion of the western edge of the park. The headwaters begin between White Wolf and Yosemite Valley at elevations between 8,000 and 8,500 feet. The South Fork Tuolumne River exits the park at an elevation of 4,500 feet, just north of Hodgdon Meadow and upstream of its confluence with the main Tuolumne River.

Influence of Fire on Watersheds

Through changes in soil and vegetative characteristics, fire influences the rate at which water flows and the volume of water in watersheds. Fire can be destructive to watershed processes, but when natural processes are allowed to occur, fire helps maintain watersheds. Fire affects several major attributes of watersheds, including water yield, peak flows, sediment yield, nutrient yield, and stream system response.

The proportion of a watershed that is burned and the proximity of the burned area to a stream channel largely determine the effects of fire on streams. A stream draining a watershed of which over 90% of the land has burned will show much greater effects than a stream emanating from a similar watershed in which only the upper slopes and ridge tops were burned. Fire intensity is often highly variable over a landscape, and patches of unburned or lightly burned vegetation (especially near streams) can reduce the adverse effects of intensely burned, upslope areas (Kattelmann 1996).

Although fire is a natural part of many ecosystems, high-intensity fire can produce some of the most extensive changes in watershed conditions of any disturbance. Intense fire kills vegetation, volatizes organic matter in the litter layer, and often forms a layer in the soil that reduces infiltration of water into deeper soil layers. The combined effect of these changes increases water yield and overland flow, possibly increasing peak flows months, or years, later. High-intensity fire may also create the conditions for shallow debris flows. Under the conditions of bare soil, increased overland flow, and lack of vegetation and litter, soil particles are transported into streams, increasing sediment loads.

Water Yield. Although the National Park Service does not manage Yosemite National Park to maximize water yield, it is a major indicator of the relative influence of fire in a watershed. Because of Hetch Hetchy Reservoir, water yield is of interest to the City and County of San Francisco.

Fire effects water yield primarily by killing vegetation and reducing the amount of water intercepted by plants, however, it also affects snow accumulation and melt rates. Plant transpiration is virtually stopped wherever a high-intensity fire has burned (Kattelman 1996). The daily cycle of plant water uptake affects hourly stream flow and this daily cycle can be changed completely by catastrophic fire. Seasonal water yield may also be affected by fire. Snow accumulation and melt rates may change after a fire. For example, melt rates would increase if more light reached the forest floor, while snow accumulation rates could either increase (small openings), or decrease (large openings). These changes may increase annual runoff in the first years after a fire.

Peak Flows. Peak flows can be expected to increase after large (relative to the watershed) fires because of increases in soil moisture caused by reduced plant transpiration, decreased soil infiltration, and higher rates of snowmelt (Kattelmann 1996).

Infiltration is usually the most important factor affecting peak flows. It is decreased in two ways. Removal of vegetation and the litter layer exposes bare mineral soil to raindrops, which can physically force the solid particles closer together and disperse soil aggregates into surface pores, thereby reducing the infiltration capacity. Secondly, fires can vaporize organic compounds in the litter layer, some of which move into the soil until the vapor condenses and forms a layer that is water repellent, or *hydrophobic*. These hydrophobic layers tend to be more coherent under very hot fires, where a thick litter layer and/or organic horizon is present, and in course textured soils, such as the decomposed granitics found in Yosemite. The continuity of these layers determines their overall impact on hill-slope water movement. Although the water repellent layers tend to break down in a year or two, those formed in soils that are hydrophobic even without fire may be more persistent. Under some conditions, a hydrophobic layer forms on the surface of the soil and acts as a binder and sealant, maximizing overland flow while minimizing erosion. Studies in the western United States have shown dramatic increases in peak flows following wildland fires.

Sediment Yield. Sediment yields increase markedly after some fires, particularly if riparian vegetation was burned (Kattelmann 1996). This increase in sediments happens through several processes. Erosion from the land surface usually increases after a fire, especially if overland flow increases—sediments may then wash into streams. In the absence of streamside vegetation, banks become less stable and soil particles move into the channels from *dry ravel erosion* (the particle-by-particle transport of material down slope due to gravity). Increases in total discharge and peak flows cause channel erosion as well. Debris torrents may scour streams if extreme climatic events follow the fire. If a fire is particularly hot, woody debris that helped stabilize the channel may be consumed, increasing water velocity and stream-bank erosion.

Nutrient Yield. During a fire, some materials are volatilized into the atmosphere, while the remainder is left as ash on and near the soil surface in forms that are readily mobile. Thus, fires provide an opportunity for nutrients that have been stored in vegetation and soils to move into streams (Kattelmann 1996). Concentrations of nitrates and other ions in streams usually increase dramatically after a fire, although the absolute amounts often remain almost negligible or at least within water quality standards. After some fires, potential is high for large nutrient losses from soil erosion carrying nutrients into streams.

Stream System Response. Both physical and biological features of streams change over time. In a fire maintained system, after a fire, initially the channel may agrade and widen in response to higher flows of water and sediment. As vegetation becomes re-established, the channel usually returns to pre-fire size within several years. In the Sierra Nevada, vegetation community similarity, density, and taxa richness will be comparable between burned and unburned reaches in one to three years after a fire (Kattelmann 1996).

Water Quality

An inventory of water quality in Yosemite revealed excellent water quality in most of the park, although some water quality degradation is occurring in areas of high visitor use (NPS 1994). Water quality is generally above state and federal standards. The surface water quality of most park waters is considered valuable by the State of California for wildlife and freshwater habitat and recreation [Central Valley Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan)].

Surface water that drains granitic bedrock in the park exhibits considerable variability in chemical composition, despite the relative homogeneity of bedrock chemistry (Clow et al. 1996). Surface water in most of the Merced River basin is diluted (lacking in dissolved solids), making the ecosystem sensitive to human disturbances and pollution (Clow et al. 1996).

Good water quality is critical for the survival and health of species that are part of riparian and aquatic ecosystems. Water quality elements that affect aquatic ecosystems include water temperature, dissolved oxygen, suspended sediment, nutrients, and chemical pollutants. These elements interact in complex ways within aquatic systems to directly and indirectly influence patterns of growth, reproduction, and mobility of aquatic organisms. For example, sediment may not be directly lethal to fish, but sediment deposited on the streambed may disrupt the productivity and life cycles of fish and aquatic insects. The Merced River has been extensively monitored for water quality.

Merced River Watershed. The chemistry of surface waters in the Merced River watershed is characterized by low electrical conductivity (limited ions due to a lack of dissolved solids), near-neutral pH, low alkalinity, and low nutrient concentrations (NPS 1994). Calcium and bicarbonate are the predominant ions in the waters. Within the Merced River, major ion concentrations slightly increase downstream, but levels remain relatively low and no significant changes have been observed in pH, alkalinity, or nutrient concentrations (NPS 1994). Due to the low alkalinity of the stream water, the *buffering capacity* (ability to absorb water chemistry changes or additions) of the Merced River and its tributaries is limited.

Water quality within the South Fork watershed is very similar to that of the main stem of the Merced River. Water quality is excellent in most areas although some water quality stressors have been exhibited near human development.

Tuolumne River Watershed. Water quality of the Tuolumne River watershed is similar to that of the Merced River watershed, and generally appears to be of high quality (NPS

1994). The quality of the Tuolumne River water above Hetch Hetchy Reservoir can be attributed to the river's free flow, its location high in the watershed, its confluence of a low order of streams, and its position in an area of minimal development. Because of the reservoir's use as a water supply, the park has taken a preventive approach to watershed health and the maintenance of high water quality.

Fire and Water Quality

High-intensity Wildland Fire. The riparian systems in Yosemite are resilient and typically return to their previous condition after low-intensity fire events. High-intensity wildland fire, on the other hand, can reduce or remove protective riparian vegetation that regulates stream temperature; traps and transforms nutrients, chemicals, and sediment; and moderates the flow of organic materials (stems, leaves, insects, microorganisms, etc.). Catastrophic fire also increases the amount of flowing water on exposed bare soils, causing erosive overland flow (*sheetflow*), rills, or gullies, and substantially increasing the sediment load into streams. This accelerated loss of soil adversely affects terrestrial and aquatic ecosystems—it depletes the land of nutrients and overloads streams with sediments.

Prescribed Fire. Because prescribed fires burn under controlled fuel moisture and weather conditions, time of day, and spatial patterns of ignition, the impacts to soils and vegetation are considerably less than with high-severity wildland fires. Prescribed fires generally retain a portion of the duff layer that helps to prevent soil erosion. In contrast to the impacts from high-severity wildland fire, infiltration rates are not greatly reduced, therefore, prescribed fire treatments tend not to exacerbate overland flow. Without overland flow, movements of soil into stream channels is limited to soil creep and ravel on steep slopes, at rates only slightly higher than areas not receiving prescribed fire.

Mechanical Treatments. The potential effects of mechanical treatments on water quality decreases as the distance from streams increases. Research in Yosemite shows that, within 300 feet of a stream, activities that compacted more than 5% of the area significantly reduced the population of sediment intolerant aquatic invertebrates (McGurk and Fong 1995). Activities that prescribe stream buffers or limits to ground disturbance can control amounts of sediment reaching the aquatic ecosystem. The risk of accelerated erosion or alteration of soil conditions from mechanical fuel reduction treatments varies depending on factors such as total acres treated, method of treatment, type of equipment used, amount and type of materials yarded or piled, soil type, soil moisture conditions, degree of slope, and history of past disturbance. The primary potential source area for sediment would be ephemeral channels and skid roads, and their immediate vicinity.

Air Quality

Yosemite National Park is classified as a mandatory Class I area under the Federal Clean Air Act (42 USC 7401 et seq.). This most stringent air quality classification is aimed at protecting national parks and Wilderness areas from air quality degradation. The Act gives federal land managers the responsibility for protecting from adverse air pollution impacts on air quality and related values, including visibility, plants, animals, soils, water quality, cultural and historic structures and objects, and visitor health.

Yosemite National Park lies within three California counties: Tuolumne and Mariposa which are within the Mountain Counties Air Basin, and Madera which is within the San Joaquin Valley Air Basin—part of the San Joaquin Valley Unified Air Pollution Control District. Yosemite Valley is in Mariposa County, which is regulated by the Mariposa County Air Pollution Control District.

National Ambient Air Quality Standards. The federal Clean Air Act, as amended in 1990, requires the Environmental Protection Agency (EPA) to identify national ambient air quality standards to protect public health and welfare. Standards have been set for six pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 microns (PM_{10}), and lead (Pb). In 1997, the EPA released revised national ambient air quality standards for ozone and for particulate matter less than 2.5 microns ($PM_{2.5}$). In the spring of 1999, a U.S. Court of Appeals panel remanded the new standards to the EPA for further consideration. However, in early 2001, the Supreme Court upheld the EPA's authority to set these new, more stringent standards.

While the EPA's authority to set the new eight-hour ozone standard was upheld, the Supreme Court ordered it to rework its policy for implementing the new ozone standard in non-attainment areas. Although the Court of Appeals prohibited the EPA from implementing the eight-hour ozone standard, it did note that the Clean Air Act required the EPA to finalize area designations within specific timeframes. The California Air Resources Board updated the proposed area recommendations with the most current air quality monitoring data and transmitted California's recommendations to the EPA in July 2000. These recommendations include non-attainment designations for the federal eight-hour standard for the Mountain Counties and San Joaquin Air Basins.

The pollutants are called criteria pollutants because the standards satisfy criteria specified in the Act. An area where a standard is exceeded more than three times in three years can be considered a non-attainment area subject to planning and pollution control requirements, which are more stringent than in areas that meet standards. Table 3.7 presents the federal and California ambient air quality standards. Table 3.8 shows the California and federal air quality standards attainment designation for the counties containing portions of Yosemite National Park.

While air quality in an air basin is usually determined by emission sources within the basin, pollutants transported from upwind air basins by prevailing winds can also affect it. For example, the California Environmental Protection Agency concluded that the ozone exceedences in 1995 in the southern portion of the Mountain Counties Air Basin (i.e. Tuolumne and Mariposa Counties) were caused by transport of ozone and ozone precursors from the San Joaquin Air Basin. Air quality in the Mountain Counties Air Basin also is affected by pollutant transport from the metropolitan Sacramento and San Francisco areas.

Table III-7
Federal and California Ambient Air Quality Standards

Pollutant	Averaging Time	Federal Standards		California Standards	Objective
		Primary	Secondary		
Ozone (O_3)	1-hour	0.12 ppm (235 μg/m^3)	0.12 ppm (235 μg/m^3)	0.09 ppm(180 μg/m^3)	To prevent breathing difficulties, eye irritation, and biological effects to sensitive species
	8-hour	0.08 ppm (157 μg/m^3)	0.08 ppm (157 μg/m^3)	NS	
Carbon Monoxide (CO)	1-hour	35 ppm (40 mg/m^3)	35 ppm (40 mg/m^3)	20 ppm (23 mg/m^3)	To prevent carboxyhemoglobin levels greater than 2%
	8-hour	9 ppm (10 mg/m^3)	NS	9.0 ppm (10 mg/m^3)	
Nitrogen Dioxide (NO_2)	1-hour	NS	NS	0.25 ppm(470 μg/m^3)	To prevent breathing difficulties, reduce smog formation, and improve visibility
	Annual Average	0.053 ppm (100 μg/m^3)	0.053 ppm (100 μg/m^3)	NS	
Sulfur Dioxide (SO_2)	1-hour	NS	NS	0.25 ppm (655 μg/m^3)	To prevent increased respiratory disease, acid

Pollutant	Averaging Time	Federal Standards: Primary	Federal Standards: Secondary	California Standards	Objective
	3-hour	NS	0.5 ppm (1300 µg/m^3)	NS	rain, crop damage, and odor nuisance, and to improve visibility
	24-hour	0.14 ppm (365 µg/m^3)	NS	0.04 ppm (105 µg/m^3)	
	Annual Average	0.03 ppm (80 µg/m^3)	NS	NS	
Respirable Particulate Matter (PM_{10})	24-hour Average	150 µg/m^3	150 µg/m^3	50 µg/m^3	To prevent chronic diseases of the respiratory tract and improve visibility
	Annual Mean	50 µg/m^3 (arithmetic)	NS	30 µg/m^3 (geometric)	
Fine Particulate Matter ($PM_{2.5}$)	24-hour	65 µg/m^3 (arithmetic)	65 µg/m^3 (arithmetic)	NS	
	Annual Mean	15 µg/m^3 (arithmetic)	15 µg/m^3 (arithmetic)	NS	
Lead	30-day Average	NS	---	1.5 µg/m^3	To prevent neurological system damage
	Calendar Quarter	1.5 µg/m^3	1.5 µg/m^3	NS	
Sulfates	24-hour	NS	NS	25 µg/m^3	To improve visibility and prevent health effects
Visibility-Reducing Particles	One Observation	NS	NS	No reduction in prevailing visibility to <10 miles when relative humidity <70%	
Hydrogen Sulfide	1-hour	NS	NS	0.03 ppm (42 µg/m^3)	To prevent odor nuisance

ppm = parts per million, µg/m^3 = micrograms per cubic meter, NS = No standard

California Ambient Air Quality Standards. To protect public health and welfare, the California Air Resources Board has set stricter ambient air quality standards than national standards. Under the 1988 California Clean Air Act, air basins were designated as attainment, non-attainment, or unclassified for the state standards.

State Implementation Plan. State implementation plans define control measures that are designed to bring areas into attainment. Currently, Mariposa and Tuolumne Counties are in attainment or are unclassified for all national ambient air quality standards, but Madera County is in non-attainment for the PM_{10} and ozone national ambient air quality standards. Basic components of a state implementation plan include legal authority, an emissions inventory, an air quality monitoring network, control strategy demonstration modeling, emission limiting regulations, new source review provisions, enforcement and surveillance strategies, and other programs necessary to attain standards.

Table III-8
Status of Ambient Air Quality Designations

A = **A**ttainment **N** = **N**on-attainment **U** = **U**nclassified

Pollutant	Tuolumne County		Mariposa County [a]		Madera County	
	California	Federal	California	Federal	California	Federal
Ozone (one-hour) (O_3)	N	U/A	N	U/A	N	N
Carbon monoxide (CO)	A	U/A	U	U/A	U	U/A
Nitrogen dioxide (NO_2)	A	U	A	U	A	U/A
Sulfur dioxide (SO_2)	A	U	A	U	A	U

Particulate matter	U	U	N	U	N	N
Lead [b] (Pb)	A	—[b]	A	—[b]	A	—[b]

a Yosemite National Park portion of Mariposa County
b EPA does not designate areas for the lead standard in the same manner as for other pollutants. However, there are no areas in California that exceed the national standard for lead.

Applicable Air Quality Rules, Regulations, and Guidelines. The California Air Resources Board is responsible for disseminating regulations about air quality, including state ambient air quality standards and area designations, emissions from motor vehicles, fuels and consumer products, and airborne toxic control measures. Title 17 of the California Code of Regulations, titled Smoke Management Guidelines for Agricultural and Prescribed Burning, provides direction to air pollution control and air quality management districts (air districts) for the regulation and control of agricultural burning, including prescribed burning. The guidelines are intended to provide for the continuation of prescribed burning as a resource management tool, while minimizing smoke impacts on the public. Local and regional authorities have the primary responsibility for control of air pollution from prescribed burning. These agencies and the regulatory citations that address prescribed burning are:

Mariposa County:	Mariposa County Air Pollution Control District, Rule 307 – Wildland Vegetation Management Burning
Tuolumne County:	Tuolumne County Air Pollution Control District, Rule 307 – Wildland Vegetation Management Burning
Madera County:	San Joaquin Valley Unified Air Pollution Control District, Rule 4103 – Open Burning

These air district rules generally specify that the agency planning a prescribed fire must notify the air district and provide burning location, acreage, vegetation type, fuel conditions, schedule, location of sensitive receptors, and other information. Fees may also be required.

The EPA has developed regional haze regulations to improve visibility or visual air quality in national parks and Wilderness areas across the country (US EPA 1999). In developing these rules, the EPA recognized that fires of all kinds, including prescribed fire and wildland fires, contribute to regional haze and there is a complex relationship between what is considered a natural source of fire versus a human-caused source of fire. Given that in many instances the purpose of prescribed fires is to restore the natural fire regime to forest ecosystems, the EPA is working with states and federal land managers to support development of enhanced smoke management plans to minimize the effects of fire emissions on pubic health and welfare.

National Park Service Guidance and Policies. As noted earlier (Chapter 1, Purpose And Need), a principal management objective is to manage air quality effects of prescribed fires by working with county and state air resources personnel and using the latest technology to monitor and manage the amount of smoke reaching visitors, residents, and employees. In addition to complying with state and local air quality rules and regulations, the National Park Service also has developed guidance on air quality and smoke management related to wildland and prescribed fires (NPS 1999b). This is supplemented by guidance and policies from the EPA. These include the Interim Air Quality Policy on Wildland and Prescribed Fires, Federal Wildland Fire Management Policy, and PM_{10} Natural Events Policy. In 1998, the EPA developed an interim policy for addressing impacts of managed wildland fires and prescribed fires on public health and welfare.

Ambient air quality below the national ambient air quality standards for $PM_{2.5}$ and PM_{10} is used as the principal indicator of adverse impacts to public health. Poor visibility is used as the principal indicator of adverse impacts to public welfare. This policy complements the Natural Events Policy, which addresses public health impacts from wildland fires.

Sensitive Receptor Areas. One objective of the California Air Resources Board and National Park Service mandates and policies is to minimize smoke impacts on people and *sensitive receptor* areas in and near the park. Sensitive receptor areas can include towns, villages, hospitals, schools, nursing homes, shopping centers, campgrounds, recreational areas, trails, public events, scenic vistas, and Class I areas. Selection was based on guidance from the California Code of Regulations Title 17, Smoke Management Guidelines for Agricultural and Prescribed Burning and by assessing regional demographics and population dynamics, local wind patterns, climatic conditions, smoke transmission/fire behavior, and input from affected air districts.

Yosemite National Park Inventory of Air Pollution Emission Sources. Air quality in the park is affected by internal and external air pollution sources. Internal air pollution sources include mobile sources and stationary sources (furnaces, boilers, and woodstoves). External air pollution sources or area sources include campfires, barbecues, and prescribed and wildland fires.

Most of the stationary and area sources are associated with the operations of the National Park Service and the Yosemite Concession Services Corporation; however, most campfires are controlled by visitors. Emissions associated with visitor vehicles and tour buses constitute the largest sources of mobile source emissions in Yosemite Valley and other heavily visited areas.

There is a number of air quality monitoring stations in and near the park. Monitors in the park include an ozone monitor and an Interagency Monitoring of Protected Visual Environments (IMPROVE) site at Turtleback Dome and a particulate monitor at park headquarters near the visitor center in Yosemite Valley. Table 3.9 lists the monitors near the park.

Table III-9
Air Quality Monitoring in the Vicinity of Yosemite National Park

State	County	Community	Pollutant[a]				
			PM_{10}	SO_2	O_3	CO	NO_2
California	Fresno	Clovis	x		x	x	x
		Fresno	x	x	x	x	x
		Parlier			x		x
		Shaver Lake			x		
	Madera	Madera			x		x
	Mariposa	Yosemite National Park	x		x		
		Jerseydale			x		
	Merced	Merced			x		x
	Mono	Lee Vining	x				
		Mammoth Lakes	x		x	x	
		Mono Lake	x				
	Tuolumne	Sonora			x	x	
Nevada	Douglas	State Line	x		x	x	x
		Minden	x				
		Gardnerville	x				

a PM10 = Suspended Particulate, SO2 = Sulfur Dioxide, O3 = Ozone, CO = Carbon Monoxide, NO2 = Nitrogen Dioxide

According to the latest California Air Resources Board air monitoring data (table 3.10), ambient air quality exceeded the state 1-hour ozone standard during three days in 2000, which compares to ten days in 1998, at the Turtleback Dome monitoring station. If the new eight-hour ozone national standard were in effect, the standard would have been exceeded nine, four, and six times in 1998, 1999, and 2000, respectively. The Yosemite Valley monitoring station exceeded the state 24-hr PM_{10} standard in 1999 on two days and in 2000 on one day. No exceedences of the PM_{10} federal 24-hr annual standard were recorded for those years at this station.

Table III-10
Highest Recorded Ozone and PM_{10} Measurements at Yosemite National Park

	Year					
	1998		1999		2000	
Highest Hourly Ozone Measurement (ppm)						
Highest	Sep 2	0.106	Jun 28	0.096	Aug 3	0121
2nd Highest	Aug 12	0.104	Jul 12	0.095	Aug 2	0.110
3rd Highest	Aug 5	0.103	Jul 14	0.095	Jul 12	0.095
4th Highest	Aug 25	0.103	Sep 15	0.095	Jun 16	0.093
Days Exceeding California Standard	10		4		3	
Days Exceeding National Standard	0		0		0	
8-Hour Ozone Averages (ppm)						
Highest	Aug 25	0.099	Jul 12	0.089	Aug 3	0099
2nd Highest	Sep 2	0.098	Jul 23	0.087	Aug 2	0.097
3rd Highest	Aug 5	0.094	Jul 27	0.087	Jul 12	0.090
4th Highest	Aug 12	0.094	Jun 23	0.085	Jun 16	0.087
Days Exceeding National Standard	9		4		6	
Particulate Matter or PM_{10} ($\mu g/m^3$)						
Highest	Sep 2	40	Jan 6	82	Jan 1	60
2nd Highest	Jan 27	39	Jan 12	74	Jan 7	42
3rd Highest	Jul 16	37	Oct 3	47	Jan 4	39
4th Highest	Oct 6	37	Jun 17	46	Feb 6	37
Days Exceeding California Standard	0		2		1	
Days Exceeding National Standard	0		0		0	

Conformity Rule. In 1993, the EPA adopted regulations implementing section 176 of the Clean Air Act, as amended. Section 176 requires that federal actions conform to state implementation plans for achieving and maintaining the national standards. Federal actions must not cause or contribute to new violations of any standard, increase the frequency or severity of any existing violation, interfere with timely attainment or maintenance of any standard, delay emission reduction milestones, or contradict State Implementation Plan requirements. The conformity rule applies only in federal non-attainment areas, such as Madera County. However, the California Air Resources Board indicates that Mariposa County, which includes Yosemite Valley, is likely to be declared a non-attainment area for the new eight-hour ozone standard in the near future, at which time conformity must be demonstrated.

Cultural Environment

Cultural resources in Yosemite National Park and the El Portal Administrative Site (the "project area") include prehistoric and historic archaeological sites, historic sites and structures, cultural landscapes, and traditional cultural properties or ethnographic resources (both natural and cultural resources) that are important to the continuing culture and traditions of park-associated American Indian people. Some of the cultural resources are housed in museum collections. These resources reflect early settlement, use, and management of the lands by indigenous people; westward expansion of Euro-American people (as well as Asian and other non-European people) and their conflict with American Indian groups; resource extraction such as logging, mining, and herding; early tourism; early environmental conservation efforts; development of water resources; and park planning, design, and land management—they are the physical evidence of human presence spanning the majority of the Holocene.

While Yosemite National Park holds important museum collections, these are not discussed in depth in the *Final Yosemite Fire Management Plan/EIS* because they are not generally affected or threatened by wildland or prescribed fire management practices. However, actions associated with implementation of elements of the alternatives could indirectly affect the museum collections. Such changes would typically involve additions to the collections generated from archaeological data recovery conducted as mitigation for direct site impacts. These changes would be minimal and would require additional museum storage space and ongoing collections maintenance and management. Specific facilities designed for museum collections preservation and protection, and are addressed in other documents such as the *Structural Fire Management Plan* and the *Collections Management Plan*.

The following discussion of cultural resources is based on general overview studies and specific cultural resource research (Hull and Moratto 1999; NPS 1987a, 1990b, 1998c, 2000d, 2001b). It is important to note the limitations inherent in the information about cultural resources. Yosemite National Park lacks three key overview studies: an overview and assessment of ethnographic resources, cultural affiliation studies, and an administrative history. Yosemite is also lacking a systematic inventory of ethnographic resources, although Bibby (1994) conducted an evaluation of ethnographic resources in Yosemite Valley. Some limited, anecdotal information regarding ethnographic resources is available for other park areas. Only about 8% of the park has been inventoried for archaeological sites; within this area 1,375 sites have been recorded. While most historical eras and events are documented, the location, extent, condition, and significance of many of the physical resources reflecting these episodes are unknown. The exception is part of the park's Wilderness area, where approximately 2,000 historic resources have been recorded. The documentation available for known resources typically lacks data necessary to determine whether there is potential for fire-related impacts to occur.

Of the known physical resources, many of the historic structures are either listed or considered eligible for listing in the National Register of Historic Places. Few archaeological sites have been individually nominated for listing in the National Register, but many areas with site concentrations have been listed or determined eligible for listing.

The build-up of fuels from years of fire suppression in some areas of the park puts many cultural resources at risk from damaging effects of high-intensity fire. However, it is likely that, except for the archaeological resources from the late 1800s and early 1900s, archaeological sites have been burned over in the past. Therefore, the susceptibility of these sites to fire depends on fuel accumulation near each site and the types of resources present that might be affected by fire. Many of the park's historical resources, however, may not have been exposed to fire. Wooden buildings, blazed trees, and other flammable historical resources are the most susceptible to damage from fire and require the most intensive management during wildland fires. To facilitate decision making during a fire event, a set of digital cultural resource maps has been developed and incorporated into the park's geographic information system (GIS). This information is currently available for prescribed fire planning and to incident commanders during wildland fire situations. Details about the types of resources and effects of fire are presented in Chapter 4, Environmental Consequences. The remainder of this chapter provides a framework for discussing the specific cultural resources in Yosemite that require special consideration in fire management.

Human Occupation

American Indian Occupation

Preliminary archaeological evidence indicates people may have been living in the area now comprising Yosemite National Park and the El Portal Administrative Site as long as 9,500 years ago. The park area contains thousands of archaeological sites, evincing technological change through time, a highly developed trade network, at least one population replacement, and significant environmental manipulation through the use of fire. The arrival of the Spanish in California in the late-18th century brought profound changes. As a result of Spanish colonization and continuing after the independence of Mexico, which included the Territory of California, American Indians from the foothill and coastal regions migrated to the Sierra Nevada—bringing with them European goods and diseases and aligning themselves with tribes already living there.

When Euro-Americans first entered Yosemite Valley in 1851, American Indians living there were most likely a mixture of Southern Sierra Miwok, Mono Lake Paiute, and Central Sierra Miwok, as well as former Mission Indians likely from Yokuts, Plains Miwok, and Ohlonean groups. The upland areas of the Merced River drainage were frequented by Southern Sierra Miwok, possibly Mono Lake Paiute, and at least traversed by Western Monos and possibly Chukchansi Yokuts. El Portal was inhabited by Southern Sierra Miwok people. The Wawona area was home to Southern Sierra Miwok people, and perhaps some Western Mono and Chukchansi Yokuts. The Tuolumne watershed area was home to Central Sierra Miwok, Southern Sierra Miwok, Mono Lake Paiute, and Bridgeport Paiute.

Euro-American Occupation

Euro-American use of the Yosemite area has been relatively short in the span of human occupation. During this brief time, many large-scale changes have occurred, which have dramatically altered the landscape. While Euro-Americans passed through the Yosemite area beginning in the 1830s, it was not until the mid-1850s and 1860s that the natural scenery of Yosemite Valley was brought to America's attention. By 1860, entrepreneurs constructed hotels, trails, and homes; filed claims and homesteads; planted orchards and field; and built cabins in what would become Yosemite National Park. In 1864, President Abraham Lincoln and the US Congress set aside the Big Tree Grove (Mariposa Grove) and Yosemite Valley, granting them to the state of California as a public park to preserve the monumental scenic qualities of the area.

By the 1870s and 1880s roads were established to bring tourists to Yosemite Valley. During this period, settlers and entrepreneurs began extracting resources such as barium, silver, gold, while they grazed livestock and logged trees in the Yosemite Sierra. Reaction to this "exploitation" preceded the early conservation movement and lead to the congressional act establishing Yosemite National Park in 1890. The logging industry profoundly changed the forest landscapes in and adjacent to the park. Beginning in the early 1900s, the Madera Sugar Pine Company extracted timber in the Southern portion of the park. By 1912, the Yosemite Lumber Company was surveying railroad routes to the Alder Creek area where it owned land within the park boundaries. In addition to the large scale logging industries, many smaller logging operations worked in the forests of Yosemite Valley, Aspen Valley, Canyon Ranch, Foresta, and Wawona.

Beginning in 1933, the Civilian Conservation Corps under the auspices of the Public Works Administration also completed an extensive range of projects in Yosemite, including construction of roads, trails, bridges, fire roads, fire buildings, fire lanes, fire trails, comfort stations, and campgrounds. Additional projects included river and creek bank stabilization, revegetation, extensive landscaping, and debris cleanup.

Fire in Early Yosemite History. While it has been hypothesized that the reduction in fire frequencies seen in the early 1800s was due to the decline in American Indian population, the use of anthropogenic fire did not stop when the Euro-Americans arrived. Fire was used by miners during the gold rush era to aid in general land clearing (Caprio and Swetnam 1995; Kilgore and Taylor 1979; UC Davis 1996e). John Muir (1938) noted "fire was also heavily employed by the early sheep and cattle men who pastured their herds in the mountains and burned the land behind them as they descended from the mountains each year."

By the mid- to late-19th century fire was seen by most as "dangerous" and ecologically devastating. The 1866 California State Legislature Act that accepted the Yosemite Grant stipulated that:

It shall be unlawful for any person willfully to … cut down or carry off any wood, underwood, tree, or timber, or girdle, or otherwise injure any tree or timber, or deface or injure any natural object, or set fire to any wood or grass upon said premises…Any person committing either or any of said acts … shall be guilty of a misdemeanor, and on conviction thereof, shall be punished by fine, not exceeding five hundred dollars, or by imprisonment in the County Jail…

~ (Commissioners 1867: 24)

The impacts of fire suppression soon changed the scenic qualities for which Yosemite Valley was set aside. The dichotomy between suppressing fire and wanting open, "park-like grounds" can be seen as early as 1880 when J. M. Hutchings, in his Report of the Guardian, stated: "A dense growth of underbrush, almost from one end of the Valley to the other, not only offends the eye and shuts out its magnificent views, but monopolizes and appropriates its best land, to the exclusion of valuable forage plants and wild flowers" (Commissioners, 1880: 7). He goes on to state the danger of fire, while setting a policy of fire suppression and selected thinning and pile burning which would stand for almost one hundred years:

This magnificent forest of giant forms [the Mariposa Grove of Big Trees], commanding, as it deservedly does, the admiration of every beholder, is in great danger of being irreparably injured, if not destroyed, by fire. Immense masses of rotten wood, and of fallen trees, full of pitch, lie immediately contiguous to, and, in many instances, directly against the base of these noble monarchs, inviting their destruction, should fire ever enter their impressive precincts. There can be but little doubt that no time should be lost in removing this inflammable material to a safe distance, and carefully burning it, to protect this wonderful grove from destruction

~ (Commissioners 1880: 9).

The conflicts surrounding the encroachment of underbrush and buildup of fuels and the appropriate use of fire has been a continuing struggle since the cessation of American Indian burning practices.

Archaeological Resources

In general, archaeological sites are important for the information they can provide regarding prehistoric and historic lifeways. They are also important to people as a tangible link with the past. Prehistoric sites in Yosemite generally contain: flaked and ground stone tools, waste from tool manufacture, food processing features, fire hearths, structural remains, human burials, and rock art. Historic archaeological sites provide important information not available in written records, such as cultural patterns typically omitted from historical literature (related to gender and ethnic groups), early building construction techniques, lifestyles of early settlers, trade and procurement of goods and materials, and interactions with native peoples. Historic sites include such things as structural remains, waste dumps, work camps, and remains of logging, hydrological manipulation, and mining activities.

Table III-11
Archeological Surveys and Known Sites in 1990 Fire Management Plan Zones

Fire Management Zone	% of Zone Surveyed	Acres Surveyed	Known sites
Suppression	24 %	26,331	612
Prescribed Natural Fire	8 %	25,726	767
Conditional	4%	4,473	67

In most cases, archaeological inventories have been conducted in support of park development projects. Most of this work has focused on lower elevation developed areas and road corridors. The archaeological database is, thus, not a representative sample of the park (Hull and Moratto 1999). The lack of surveys extends to the existing fire management zones (table 3.11 and map 3-3).

In general, archaeological resources are at greater risk of damage and/or loss from high-intensity burns than low-intensity burns. The heavy fuel loads and unnaturally dense forest stands existing in parts of Yosemite today, decrease ground visibility, which in turn decreases the probability that archaeological resources will be detected during inventories. Large fuel loads also increase the risk of high-intensity wildland fires, thus increasing the potential for damaging archaeological resources.

Recent studies on the historic American Indian use of fire (Anderson and Moratto 1996) suggest that fires lit by American Indian would have been centered around late prehistoric and protohistoric occupation sites. It is possible this pattern of land management also extends into the more distant past and areas surrounding many of the prehistoric occupation sites may have been subject to a greater degree of fire than similar areas that did not contain such occupation sites (Wickstrom and Roper 1987). The extent of fire, both lightning- and American Indian- ignited, prior to 20th century suppression efforts makes it likely that many prehistoric archaeological resources have been repeatedly exposed to fire in the past. Therefore, we can assume most of the damage that could occur to these archaeological sites from low-intensity fires has already occurred at many of these sites. A prescribed fire regime, that maintains relatively light fuel loads, can therefore actually protect many archaeological sites from damage of intense wildfires (Jackson 1997).

Ethnographic Resources

The National Park Service defines ethnographic resources as any "site, structure, object, landscape, or natural resource feature assigned traditional, legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it" (NPS 1998a). A traditional cultural property is an ethnographic resource that is eligible for listing in the National Register of Historic Places. Two places in Yosemite Valley have been proposed as traditional cultural properties.

Many American Indian people and groups continue their traditional cultural association with park lands and resources. At least seven federally recognized tribal groups and nonrecognized American Indian communities are associated with the park. These park-associated tribes and groups include the American Indian Council of Mariposa County, Inc. (Southern Sierra Miwok); the North Fork Mono Rancheria; the Tuolumne Band of Me-Wuk Indians; the Picayune Rancheria; the Mono Lake Indian Community; the Bridgeport Paiute Indian Colony; and the Bishop Paiute Tribe.

The National Park Service consults with park-associated American Indian tribes and groups regarding annual fire programs and in emergency wildland fire situations. In general, American Indian groups have expressed concern about landscape changes caused by fire exclusion, the abundance and vigor of traditionally used plants (many of which were managed by fire), damage to traditionally used plants resulting from cutting or burning in the wrong season, and protection of archaeological objects and features—both from damaging effects of heating and direct impacts associated with fire management activities (thinning trees, building hand-lines, etc.).

Based on consultations with American Indian tribes and groups as well as research related to American Indian use of fire, park objectives to manage cultural resources are to develop project-specific objectives. Mitigating measures related to ethnographic resources will be taken where necessary and appropriate, in consultation with park-associated American Indian tribes and groups.

American Indian Use of Fire to Influence the Environment. American Indians have intensively managed biotic resources in the Sierra Nevada for thousands of years. Resource management practices were widespread, producing ecological and evolutionary consequences in ecosystems of the region (Anderson and Moratto 1996). In order to meet their requirements for firewood, fish and game, plant foods, craft supplies, and building materials, American Indian peoples shaped the distribution, structure, composition, and extent of certain plant and animal communities. This was accomplished using proto-agricultural techniques such as pruning, sowing, weeding, tilling, selective harvesting, and burning.

Fire was the American Indians' most important management tool in the Yosemite region, and was used most commonly in the foothill woodland, chaparral, mixed conifer, riparian corridors, and meadow vegetation types. Generally fire was used "to clear brush, maintain grasslands and meadows, improve browse for deer, enhance production of basketry and cordage materials, modify understory species composition in forests, and reduce fuel accumulation that might otherwise sustain intense fires" (Anderson and Moratto 1996). Fire was used to foster desirable attributes in certain plants and "individual shrubs or clusters of shrubs were burned to manipulate the plant architecture and keep the plants insects and pathogen-free" (Anderson 1993).

In addition, "burning at higher elevations was for the expressed purpose of removing shrub and duff layer… causing ephemeral creeks and streams to run longer in the summer" (Anderson and Moratto 1996). Fire was also used in hunting and driving small mammals, insects, and birds. The broad result of American Indian-based management was continuous introduction of small disturbance regimes that created openings or clearings in various plant community types. These clearings allowed early-seral plants to grow in, which created a greater diversity of species and increased productivity.

In areas where American Indians lived, fuel loads and forest conditions were further altered by daily firewood use. Anderson and Moratto (1996) estimate that each household would have used an average of 10 kg (22 lb) of firewood each day. Some larger villages (300 to 500 members) could use 250 metric tons of firewood annually.

Use of fire by American Indians may have encouraged a diverse habitat near areas of human habitation. For these and other reasons noted above, it is critical that land managers understand American Indian burning objectives and practices for management of different plants and landscapes. It is only with an understanding of these previous human-based disturbance regimes that current land managers can assess current landscape conditions and re-integrate fire into the ecosystem.

Cultural Landscape Resources (Including Historic Sites and Structures)

A cultural landscape is a reflection of human adaptation and use of natural resources and is often expressed in the way land is organized and divided, patterns of settlement, land use, systems of circulation, and the types of structures that are built. Shaped through time by historical land use and management practices, as well as politics and property laws, levels of technology, and economic conditions, cultural landscapes provide a living record of an area's past, a visual chronicle of its history. The National Park Service defines and actively manages four types of cultural landscapes: designed landscapes, vernacular landscapes, historic sites, and ethnographic landscapes (NPS 1998a). Sixty-five potential cultural landscapes are identified within the park.

Preservation of cultural landscapes requires long-term management of the characteristics and features that give them their historical significance. These characteristics are not managed in isolation but as a whole. What makes the cultural landscape significant is the relationship among isolated features such as roads and fences, orchard trees and outbuildings, grinding stones and house remains. In this regard, protection of cultural landscapes in fire regimes requires a broad view of effects and holistic preservation strategies.

Historic structures are significant because they reflect important eras or the influence of individuals important in the human history of the park. Five National Historic Landmarks are located in Yosemite: The Ahwahnee, the LeConte Memorial Lodge, Parsons Memorial Lodge, the Rangers' Club and garage, and the Wawona Hotel. These reflect the highest level of historic significance. The National Park Service is charged with maintaining all historically significant structures to prevent any degradation of significant characteristics. The List of Classified Structures (1998c) for Yosemite identifies nearly 500 historic structures. Many of these are listed or eligible for listing on the National Register of Historic Places. The existing accumulation of burnable materials across Yosemite's landscape means that many historic sites such as homesteads, mining cabins, railroad grades, and other resources – and the information contained within these historic sites – are at risk of being lost to wildland fires.

Although the park lacks a comprehensive, parkwide inventory of historic sites and structures, there is a great deal of information about Yosemite's historical resources. An overview of historic resources was conducted in 1987 and an inventory of historic resources in Wilderness areas was conducted in the late 1980s and early 1990s (NPS 1989, 1990). Approximately two thousand historic trails, tree blazes, buildings, structures, and miscellaneous features were documented. In addition, comprehensive inventories and evaluations of historic sites, structures, and cultural landscape resources have been undertaken for Yosemite Valley and El Portal (NPS 1994, 1998b, 2001). Many different historic resource property types are documented (and expected) in Yosemite (Hull and Moratto 1999).

Social Environment

Recreation

This topic describes the relationship between fire management activities and recreation in Yosemite National Park. It provides the basis for the subsequent evaluation of recreational issues, as they are influenced by routine fire management activities, such as prescribed fire, managed wildland fires, and fuel reduction. Yosemite National Park, as guided by its enabling legislation and the National Park Service Organic Act of 1916, has two interwoven purposes:

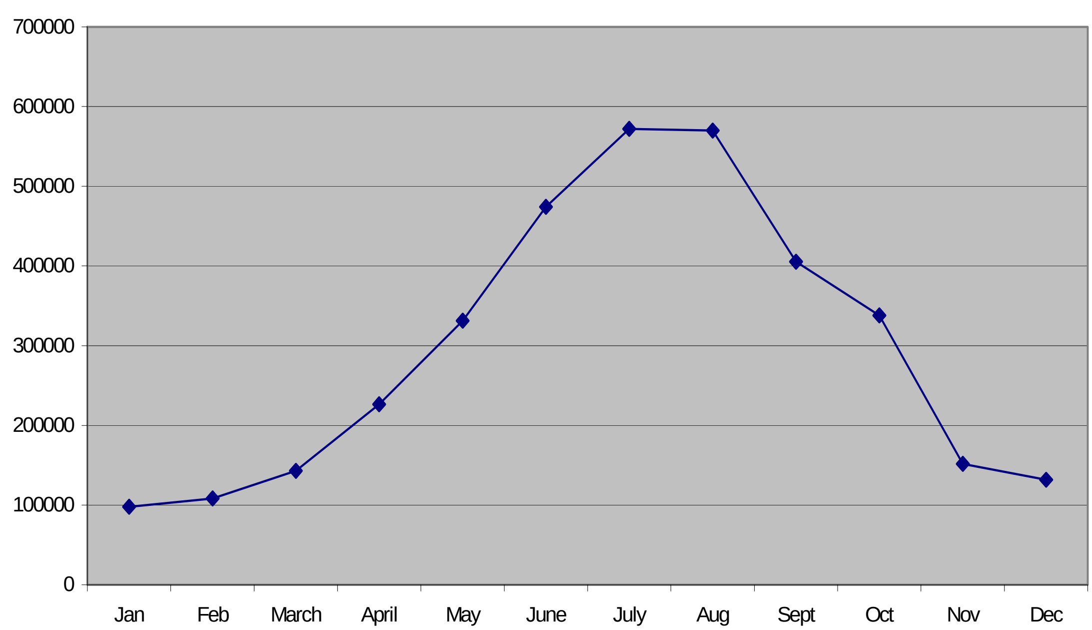
The first is the preservation of the resources that contribute to Yosemite's uniqueness and attractiveness its exquisite scenic beauty; outstanding Wilderness values; a nearly full diversity of Sierra Nevada environments, including the very special sequoia groves; the awesome domes, valleys, polished granites, and other evidences of the geologic processes that formed the Sierra Nevada; historic resources, especially those relating to the beginnings of a national conservation ethic; and evidences of the Indians who lived on the land. The second purpose is to make the varied resources of Yosemite available to people for their individual enjoyment, education, and recreation, now and in the future.

~ (1980 General Management Plan)

Visitor Use

For the last decade, park visitation has been between 3.5 and 4.1 million people annually. Most people come during late spring through early autumn. Over half of Yosemite's visitors enter Yosemite Valley. Visitation to Yosemite increased steadily from 1990 through 1996. In the aftermath of the flood of 1997, fewer people came to Yosemite, however, visitation may again be on the rise. In 2000 visitation was slightly over 3.5 million (figure 3.1)

Figure III-1
January - December 2000 Visitation, Yosemite National Park. Number of Visitors by month. Total Visitation = 3,550,065



Fire management activities can affect visitors in several ways. Smoke is the most obvious – it can affect visitors throughout the park – especially during wildland fire season in the Sierra Nevada. Because of the need to protect people and buildings, the most heavily visited areas of the park are also the areas most impacted by prescribed burning. Visitors are most likely to be exposed to prescribed burning during the months of May and June (spring burning) and September through mid-December (fall burning). This includes work in Yosemite Valley, Wawona, and other developed areas. Visitors from late May through late October are the most likely to be exposed to the effects of wildland fires since most of these fires occur between late June and late September. Wilderness hikers may be prohibited from entering an area in which a wildland fire is burning or may elect to avoid areas because of smoky conditions.

Valley Visitation. The number of visitors to the Valley tends to vary by month in a pattern similar to parkwide visitation. More than 50% of the total annual visitors come to the Valley in July and August. During August 1998, on an average day, an estimated 10,950 day visitors and 6,383 overnight visitors were in the Valley for at least a portion of the day. Daily visitation in April averaged 7,624, that year, substantially lower than in the peak season.

Wilderness Visitation. In Yosemite, 704,624 acres are designated Wilderness. Nearly 50,000 visitors per year enter the Wilderness areas. They are the most likely to be exposed to effects from managed wildland fires. This would occur primarily between late June and late September, when the frequency of lightning fires is greatest.

The Yosemite Experience

For many visitors, driving through the park is the primary means for experiencing the spectacular views of Yosemite. And en route, the drive into the park is also usually a pleasurable experience, contributing to visitors' enjoyment of the park. Many visitors make informal stops along park roads to take advantage of the unique and varied scenery. Visitor activities in Yosemite National Park include sightseeing, walking and hiking, bicycling, climbing, stock use, picnicking, and nature photography.

Many people come to Yosemite to see the Valley's grandeur—it's waterfalls and geologic features. In the Valley the continuum of visitor experiences extends from highly social to isolated, from independent to directed, from spontaneous to controlled, from easy to challenging, and from natural to more urban. For many, the Valley provides a transition zone, a place neither urban nor Wilderness, but with elements of both. Quiet, an important characteristic of a quality visit for many visitors is sometimes difficult to find, as roads carry traffic on both sides of the Merced River for nearly the entire length of the Valley.

Because of its limited facilities and access, many of the Valley's more natural experiences are found in the west Valley. A hiking and stock trail loops around the Valley perimeter, but bicyclists currently have access to the west Valley only by sharing roads with motor vehicles. A concessionaire-operated tram/bus tour provides narrated tours of the entire Valley for a fee, but the free shuttle bus system serves only the east end of Yosemite Valley.

For visitors to Yosemite Wilderness, the vast area allows visitors to explore and discover the natural beauty of many geologic features, the rivers, streams, lakes and many species of plants and animals. The remote areas of the Wilderness provide outstanding opportunities for solitude and a primitive and unconfined type of recreation. The Wilderness area is accessed by almost 800 miles of marked and maintained trails, as well as several hundred miles of cross-country zones. Visitor use and access is managed by trailhead quotas, through a Wilderness permit system. Camping is generally allowed anywhere in the

Wilderness provided it is at least 100 feet from any water body, and is discouraged in sensitive areas (i.e., meadows and other areas with fragile vegetation).

Fire Information

Most prescribed burns and wildland fires take place using limited closures or management restrictions. Emphasis is placed on providing information to visitors, to reduce impacts on their visit, and to promote public safety. Visitors to Yosemite National Park can use park and other information resources to receive information on the fire management activities that might have an influence upon their visit. The park's public information office and incident fire information personnel distribute information through press releases, special notices and other communications, as needed to inform other agencies, communities and individuals of fire management activities. For some fire management activities, visitors are given information at park entrance stations, while signs are used to inform visitors along major thoroughfares, including roads and trails. Staff at park visitor centers post information on cautions, closures, and restrictions, as needed, and are available to answer questions and provide interpretation regarding fire management activities and their purposes.

Scenic Resources

The visual resources of Yosemite include not only the iconoclastic views within the Valley, but also expansive views in the Yosemite Wilderness, views seen along the major roads, and views within other major destinations. Fire management activities, especially smoke, while seeming to spoil scenic views, can enhance scenic resources in Yosemite. Fires can help restore open vistas and maintain ecosystem health—thereby contributing to scenic resource values.

Visual Resources of Yosemite National Park

Yosemite Valley. Scenic resources have been studied and analyzed in Yosemite National Park since at least 1865, when a board of commissioners appointed by the governor of the State of California commissioned three artists to study and document the scenery of Yosemite. The 11 most important features within Yosemite Valley have been identified as Half Dome, Yosemite Falls, El Capitan, Bridalveil Fall, Three Brothers, Cathedral Rocks and Spires, Sentinel Rock, Glacier Point, North Dome, Washington Column, and Royal Arches (NPS 1980). Other important scenic resources viewable in Yosemite Valley include: Nevada, Illilouette, and Ribbon Falls; the cliffs at Yosemite Point/Lost Arrow Spire; and the scenic interface of river, rock, meadow, and forest throughout the Valley.

Wilderness. Visual resources in the Wilderness are less studied than those in Yosemite Valley and other developed areas, but exhibit equivalent scenic resource value. The Merced and Tuolumne watersheds and their many lakes, falls, and valleys; granite domes; and the peaks of the Sierra crest dominate the scenery of Yosemite's Wilderness. Only a small fraction of the visitors to the park ever directly experience the scenic resources beyond the view of roads and highways but the lack of people and modern intrusions enhances the beauty of the area, as well as the opportunity to enjoy these landscapes.

Major Thoroughfares. Tioga Road offers broad alpine views of meadows, domes, distant peaks, and Tenaya Lake. Exfoliating granite surfaces along the Tioga Road provide a unique view of the geologic processes at work in Yosemite. Approaching Yosemite Valley from the north and south, visitors are afforded views from above the lower canyon of the Merced River. Views from major thoroughfares are important to most visitors. Many vistas are being obscured by vegetation.

Wawona Area. Scenery in the Wawona Area includes the South Fork of the Merced River, forests, granite features such as Wawona Dome, and the Wawona Hotel and the elements (including golf course) of its historic landscape. Near views include managed landscapes throughout the private development (i.e., Section 35) downriver to the Wawona Campground.

El Portal. Scenery in El Portal includes the V-shaped Merced River gorge, with its steep, unglaciated terrain and woodland and grassland cover, and the rocky, boulder strewn, river bed.

Noise

This section describes the relationship between fire management activities and the soundscape in Yosemite National Park. For the purpose of this analysis, *noise* is defined as human-caused sound. Noise levels in any one area of the park are influenced by the number of people, the amount and type of traffic and other mechanical noise, and distance to sources of noise. Atmospheric effects such as wind, temperature, humidity, topography, rain, fog, and snow can affect the presence or absence of noise. *Natural sound* from Yosemite's waterfalls, flowing water, animals, wind, and rustling tree leaves may be quite loud, however it is not considered to be noise. Natural sound levels in Yosemite vary by location, time of day (birdsong), and season (water in the waterfalls and rivers is highest in the spring).

Whether a noise or sound is considered unpleasant depends on the individual listening; an individual's tolerance for noise, expectations of noise levels, and activity when the sound is heard (i.e., working, playing, resting, sleeping) all influence the perception of noise and sound. Noises have different effects on people depending on where they are and where the noise originates (for example, visitors are less sensitive to certain sounds in Yosemite Valley than to the same sounds when heard in Wilderness).

Existing Sound/ Noise Environment

Measurements were obtained using a Larson Davis sound-level meter (Model 700) calibrated with a Larson Davis sound-level calibrator. For the purpose of this analysis, sound and noise levels are expressed in decibels on the "A" weighted scale (dBA) because it most closely approximates the response characteristics of the human ear to low-level sound. At each measurement location observations of the background sound level were made over a period ranging from one to five minutes. In addition, observers noted the sources contributing to the background level and noted any sources that caused intrusive noises above the typical background level (NPS 2000c).

In Yosemite Valley, measured sound levels indicated that the background (minimal) sound level is 31 to 32 dBA (measured near the Upper Pines Campground in the early morning). Near rivers, when water flow is minimal, sound levels averaged 37 dBA, but near flowing water sound levels averaged 44 dBA and near cascading water sound levels averaged 55 dBA. Finally, near the base of waterfalls, sound levels averaged 68 dBA. Sound levels associated with rivers increase as the flow of water increases and in areas where rocks and waterfalls were present. Yosemite Valley noise levels ranged from 44 to 47 dBA along the Lower Yosemite Fall trail when no water was running in Yosemite Creek to 59 dBA near Happy Isles, mainly from people using trails and facilities nearby. At Upper Pines Campground, sound levels were at 55 dBA when human activity levels were high. At Devils Elbow, when the sound of the river was minimal, noise levels were 44 dBA but peaked at 67 dBA when a bus passed by on Northside Drive.

In Wawona, sound levels were measured in the middle of the old Wawona Bridge and west of the Covered Bridge near the Pioneer Yosemite History Center. Sound levels in these areas were 50 and 44 dBA, respectively, with maximum-recorded levels of 59 dBA near the old Wawona bridge.

In Yosemite, 55% of visitors surveyed about aircraft noise reported hearing aircraft sometime during their visit (NPS 1994b). Recognition of noise from aircraft was highly variable from location to location, and impacts to visitors were greater in areas with less vehicle noise and fewer people. In 1993, measurements made at four locations within the park indicated that aircraft were audible 30% to 60% of the time during each six-hour measurement period. Most overflights are from high-altitude jet aircraft.

Table III-12 shows some representative noise and sound sources, their associated dBA levels, and corresponding effects (FICN, 1992). Also listed is the relative loudness at which an average person would rate the sound sources, using noise levels during a quiet urban daytime as a reference level. For the average human, a 10 dB increase in the measured sound level is subjectively perceived as being twice as loud. The decibel change at which the average human will indicate that the sound is just perceptibly louder or perceptibly quieter is 3 dB.

Fire Management Related Sources of Noise. The noises associated with fire management activities are generally from mechanical equipment, motor vehicles, and aircraft. Machinery used and amount of noise produced while performing specific fire or fuel management activities varies by the location of the activity (different equipment is used in Wilderness than along road corridors, for example).

Mechanical Equipment. Mechanical equipment associated with fire management activities comprises both portable equipment used in remote areas and large equipment used near roads and the wildland/urban interface. Noises from chainsaws, wood chippers, and portable water pumps are very loud (table III-12) and this equipment is generally used in remote areas, away from concentrations of people or major thoroughfares. However, remote areas typically have low background noise levels and visitors are likely to be more noise sensitive. Noise from large mechanical equipment, like feller-bunchers, is similar to that of a caterpillar (table III-12). These are likely to be used where background noise and expectations of noise would be higher, such as near roads in wildland/urban interface communities.

Table III-12
Sound Levels and Relative Loudness of Typical Noise Sources

dB(A)	Source	Relative Loudness	Human Judgment
115	Pneumatic Chipper at 1 meter[1]		Uncomfortably loud
100	Bell J-2A Helicopter at 100ft.	128 times as loud	Uncomfortably loud
100	Chainsaw[2]	128 times as loud	Uncomfortably loud
90	Motorcycle at 25 feet	32 times as loud	Very loud
85	D8 Caterpillar dozer at 50 feet		
80	Diesel truck, 40 mph at 50 feet	16 times as loud	Loud
75	Average car, 40 mph at 25 feet		
65	Conversation at 3 feet		
50	Quiet residential	Twice as loud	
45	Bird calls	Quiet	
40	Lower limit urban daytime ambient	**Reference loudness**	
30	Background quiet suburban at night	1/2 as loud	
20	Quiet whisper	1/4 as loud	Barely Audible
0	Threshold of hearing		

Sources: FICN, 1992, except: 1 Canadian Centre for Occupational Health and Safety; 2 National Institute for Occupational Health and Safety.

Motor Vehicle Noise. Fire management vehicles include pickup trucks and wildland fire engines (trucks equipped with water tanks, pumps, and hoses). The noises associated with use of these vehicles would be similar to the noise from automobiles, recreational vehicles, commercial buses, shuttle buses, and trucks using the park road system. Noise from motor vehicles is obviously loudest immediately adjacent to the roadways, but due to generally low background sound levels in much of Yosemite, can be audible a long distance from the roads. Noise levels from motor vehicles will be loudest where and when activity levels are the greatest.

Aircraft Noise. Aircraft are often used in fire management activities. Helicopters are used to move equipment and personnel for managing and monitoring wildland fires. The National Park Service also uses helicopters in carrying out its other responsibilities, including search and rescue, medical evacuations, law enforcement, and other special operations (NPS 1993). Helicopter noises can be quite loud (table 3.12) and intrusive.

Socioeconomics

This section examines the social and economic environments that may be affected by the alternatives. The discussion covers local communities in and near Yosemite and emphasizes characteristics that have the potential to be affected by fire management activities in and around the park.

The effected environment includes the five primary gateway counties to Yosemite National Park: Madera, Mariposa, Merced, Mono, and Tuolumne Counties. The four main access roads to the park pass through all five gateway counties: Highway 41 through Madera and Mariposa Counties, Highway 140 through Mariposa and Merced Counties, Highway 120 east through Mono County, and Highway 120 west through Tuolumne County (map 1.1). The affected environment generally includes those cities within 100 miles, or two and one half hours driving time, from Yosemite Valley, which is used as the central measuring point for the park. Travel and lodging expenditures within the 100-mile radius of Yosemite Valley are likely to be Yosemite-related, since the park is the dominant tourist destination in the region (Dornbusch & Company, Inc. 1999).

The main developed areas within park boundaries and the El Portal Administrative Site are in Mariposa County. Communities of Yosemite Village, El Portal, Wawona, Foresta, Yosemite West, and Aspen Valley are within or abutting the park or El Portal.

Stanislaus, San Joaquin, and Fresno Counties were excluded from the analysis because it is difficult to distinguish the portions of the tourist economies of these counties that are associated with Yosemite visitation versus other tourist destinations. Also, tourism is a relatively small component of these counties' overall economies.

Regional Comparison

Population. In 1998, the total population of the five-county affected region was approximately 391,891 (table III-13) Merced County is the most populous county, with roughly 197,730 residents.

Table III-13
Regional Population by County

County	Population (1998)
Madera	114,748
Mariposa	15,877
Merced	197,730
Mono	10,288
Tuolumne	53,248
Total	**391,891**

Source: U.S. Bureau of the Census 1999

Table III-14
1998 Total Taxable Retail Sales by County (in millions of 1998 dollars)

County	Total Taxable Sales
Madera	$777.3
Mariposa	$122.2
Merced	$1,462.5
Mono	$157.9
Tuolumne	$408.5
Total	**$2,928.3**

Mono County is the least populous of the five counties, with about 10,288 residents, despite having the largest land area. Mariposa County has a total population of approximately 15,877 residents. Madera County has 114,748 residents, while Tuolumne County has 53, 248. The populations of all five counties in the affected region are predicted to grow steadily through the year 2040.

Taxable Retail Sales. Taxable retail sales are a good indicator of annual spending in the travel-service sectors, since they represent the taxes paid for transactions with consumers. The total taxable retail sales figures include the taxes paid by businesses on raw materials and services (Dornbusch & Company, Inc. 1999). In 1998, the total taxable retail sales for the five counties was nearly $3.0 billion (1998 dollars). Merced County accounted for approximately 49.9% of total taxable sales in the five-county affected region, followed by Madera County, which accounted for 26.5%. Mariposa County, which includes service areas of Yosemite Valley, El Portal, and Wawona, accounted for about 4.2% of total taxable sales. Table 3.14 shows total taxable retail sales by county.

Visitor Spending. Table 13.15 provides estimates of total Yosemite visitor spending within the Yosemite region. Using estimated daily per capita spending figures for each visitor category and 1998 visitation figures, the total Yosemite visitor spending in 1998 is estimated to be approximately $240 million (1998 dollars). This figure represents only Yosemite visitor spending in the park and surrounding region. Yosemite visitors staying overnight outside of the affected region are recognized as day visitors. As a result, their spending on lodging and other services outside the affected region is not included (Dornbusch & Company, Inc. 1999).

Table III-15
Total Spending by Yosemite Visitor Population Categories in 1998 (in 1998 dollars)

Visitor Category	Average Length of Stay in Region (days/Yosemite visit)	Average Total Daily Spending ($ per capita)	Total Spending in Region ($ millions)
Park Overnighters	2.7	$61.30	$97.3
Local Overnighters	1[1]	$66.68	$102.3
Day Visitors	1	$25.54	$39.2
Total			**$238.8**

1 Local overnighter typically make multiple visits to the park during their Yosemite trip. However, each day trip into the park corresponds to one day of spending in the region.
Source: Dornbusch & Company Inc. 1999.

County Profiles

Madera County. The central economic activity in Madera County is agriculture, which constitutes nearly one-third of the county's total employment and over 20% of the county's personal income and economic output. The agricultural sector stimulates production in related sectors of the economy, including jobs in food processing, transportation, and wholesale trade (Dornbusch & Company, Inc. 1999). Total wage and salary employment in Madera County is expected to grow by approximately 22% from 1995 to 2002. Most of the new job growth is expected to be in services and manufacturing (Dornbusch & Company, Inc. 1999). The portion of the county most likely to be affected by fire management activities is located along Highway 41, including the community of Oakhurst, which is highly dependent upon tourism.

Mariposa County. The county's primary recreation area/tourist attraction is Yosemite National Park, much of which lies within the county as do the developed areas of Yosemite Valley, Wawona, and the El Portal Administrative Site. Major recreation areas in Mariposa County include Stanislaus National Forest and Sierra National Forest, including the U.S. Forest Service and Bureau of Land Management recreation areas along the Merced River. Other recreation sites in Mariposa County include Lake McSwain and Lake McClure, where camping is available (Dornbusch & Company, Inc. 1999).

Recreation and tourism are major industries in Mariposa County and lodging, food and beverage, and other service industries that cater to tourism are central to the county's economy. Tourism accounted for nearly 50% of employment and over one-third of personal income and economic output in 1996. Government is also a major economic sector in the county, accounting for 23.1% of employment, 21.7% of income, and 13.3% of total output. The finance, insurance, and real estate sector accounted for 17.9% of income and 15.3% of economic output, although only about 4% of total employment.

Merced County. Merced County, located west of Yosemite National Park, has the largest economy in the region. Agriculture is the largest economic sector in Merced County and in 1996 it accounted for over 20% of employment, 17.7% of personal income, and 19.7% of economic output. The primary commodities include milk products, chicken, and cattle. The economy has a light industry component, much of which is geared toward agricultural products (Dornbusch & Company, Inc. 1999). Merced County's primary tourist attraction, particularly for the city of Merced, is Yosemite National Park, which is located over 50 miles from the county's eastern boundary (Dornbusch & Company, Inc. 1999).

Mono County. Mono County is the primary gateway county for visitors entering through the eastern park entrance. Park access via the road is not plowed of snow and the entrance is closed in the winter from November to late May. Lodging, food and beverage, and other services are central to Mono County's economy, which is also bolstered by extensive natural resources and recreational opportunities. In 1996, approximately 50% of employment and over one-third of personal income and economic output in Mono County were provided by hotels and lodging, food and beverage, and other service industries. Mammoth Lakes, which is located in southern Mono County, is the center of the county's winter tourism industry and is the fastest growing community in the county. Related employment is erratic since it depends heavily on snowfall at Mammoth Lakes Ski Resort (Dornbusch & Company, Inc. 1999).

Tuolumne County. Yosemite National Park is in the southeastern portion of Tuolumne County. The services sector was the largest employer in the county in 1996, accounting for 24.4% of employment and over 18% of personal income and economic output. Non-farm employment in Tuolumne County is projected to grow by 15% from 1995 to 2002 as the county experiences continued population growth. Most of the job growth is expected in the services, retail trade, construction, and manufacturing sectors. The services sector is expected to create the greatest number of new jobs, reflecting an increased demand for business, health, personal, and hospitality services (Dornbusch & Company, Inc. 1999). Other recreational attractions in Tuolumne County include Columbia State Park, Stanislaus National Forest, Dodge Ridge Ski Area, and Leland Meadows.

Local Communities

The communities of El Portal, Wawona, Foresta, Yosemite West, Aspen Valley, and those in Yosemite Valley are in or abutting Yosemite National Park and the El Portal Administrative Site. There is also an administrative area at Hodgdon Meadow, at the Big Oak Flat entrance to the park, occupied by National Park Service personnel year round.

Yosemite Valley. Yosemite Valley is the park's most popular visitor destination and over 80% of self-driven tourists visit the Valley (Nelson\Nygaard Consulting Associates 1998). It is also home to park and concessionaire employees and their families. The Valley is the economic center of Yosemite National Park.

Facilities. Yosemite Valley hosts the most concentrated array of visitor services and facilities in the park. Yosemite Village is the core area for most of the development and day use in Yosemite Valley and includes a visitor center, museum, concessionaire Village Store complex and food service, and National Park Service and primary park concessionaire administration offices. Camping in Yosemite Valley is provided at six campgrounds that provide a total of 475 campsites. The three drive-in campgrounds, Upper Pines Campground, Lower Pines Campground, and North Pines Campground, operate on a reservation system though the National Park Reservation Service. Camp 4 is a first-come, first-served walk-in campground. Backpackers Campground, another walk-in campground, is reserved for pre- and post-trip nights for Wilderness permit holders. Yellow Pine is primarily a National Park Service volunteer walk-in campground. Although the campgrounds are not concession operated, campers use concession facilities located elsewhere, including showers, coin-operated laundries, stores, and restaurants. The revenue-generating services in Yosemite Valley are predominantly operated by the primary park concessionaire. Major concessionaire facilities outside of Yosemite Village include the 245-room Yosemite Lodge, 123 rooms at The Ahwahnee, the 264-unit Housekeeping Camp, the 631-unit Curry Village, and the Valley stable. The lodging facilities are accompanied by concession- operated food service and stores. The concessionaire operates several equipment-rental establishments that provide bicycles, rafts, and cross-country skis.

Employment. Approximately 20% of park employees work seasonally—most of them work during summer, the peak season. During the summer of 1998, the National Park Service employed approximately 412 people in the Valley. Each summer, the primary park concessionaire employs approximately 1,378 people in Yosemite Valley.

Population and Housing. The residential population during the peak season is approximately 1,500 (employees and their families). National Park Service employees are generally housed in single-family homes or apartments. The National Park Service provides approximately 73 housing beds in Yosemite Valley. The primary park concessionaire provides approximately 1,167 housing beds in Yosemite Valley during the peak season. There is high seasonal variation in the number of concession employees housed in the Valley, ranging from about 1,167 employees during the summer to about 800 in the winter. Most of the park concessionaire seasonal employees reside in dormitories or camps of tent cabins.

El Portal. The El Portal Administrative Site is a 1,398-acre area that was designated as an administrative area for the park in 1958. It is located on Highway 140, approximately 16 miles west of Yosemite Valley. The community of El Portal is generally considered to extend west from the Yosemite View Lodge near the Yosemite National Park boundary to Savage's Trading Post near the South Fork of the Merced River. The El Portal Town Planning Advisory Committee represents the community concerns and issues raised throughout the El Portal area. It is an official body sanctioned by Mariposa County ordinance and recognized by the National Park Service.

Facilities. El Portal functions primarily as a National Park Service employee residential area and a maintenance and utilities site. The National Park Service also has administrative and research facilities in El Portal. Concession facilities in El Portal include a small grocery store and a gas station. Concessionaires other than the primary park concessionaire operate these facilities. A 278-room hotel, with restaurant facilities and a grocery/gift store, is located on private land near the park boundary. El Portal also is the headquarters for the Yosemite Association housed in the historic Bagby train station, and the Yosemite Institute housed in the former El Portal Hotel.

Employment. The National Park Service employs approximately 263 people in El Portal. The school, grocery store, Yosemite Association, and Yosemite Institute offer additional seasonal and year-round employment.

Population and Housing. El Portal is a small community of approximately 700 residents. Individuals living in El Portal generally work for the National Park Service or the primary park concessionaire. Compared to Yosemite Valley, greater proportions of El Portal residents are married and have children. Many employees who reside in El Portal do not live in government- or company-owned housing. Many homes in Old El Portal are privately owned and are administered through the park's special-use permit program. Presently, regulations are being developed to describe the administrative relationship between these private homeowners and the National Park Service.

Wawona. Wawona is located in the southwestern portion of Yosemite National Park on the Wawona Road. The town is generally considered to encompass all developed areas within Section 35. The Wawona Town Planning Advisory Committee represents the community concerns and issues raised throughout the Wawona area. It is an official body sanctioned by Mariposa County ordinance and is recognized by the National Park Service.

Facilities. The National Park Service operates the 93-site Wawona Campground, the 2-campsite Wawona Horse Camp, and the Pioneer Yosemite History Center, which is a collection of historic buildings relocated to the Wawona area from various locations throughout the park. The National Park Service offers stagecoach rides across the Wawona Covered Bridge to the Pioneer Yosemite History Center. Concession facilities in Wawona include the 104-room Wawona Hotel complex, which features a dining room, bar, golf course, pro shop, and snack bar. Other concession facilities include a grocery store, gift shop, service station, and stables (NPS 1992).

Employment. The National Park Service employs approximately 60 people in Wawona during the peak season and the primary park concessionaire employs approximately 130 people, the majority of whom are employed at the Wawona Hotel complex.

Population and Housing. The population of Wawona varies from a summer high of about 1,000 to a winter low of about 160 residents. Many individuals living in Wawona are retired, have external incomes, and are seasonal residents. Most of the residences in Wawona are located in Section 35, which includes about 350 homes. Approximately 300 residences are privately owned (some of these residences are included in the National Park Service land acquisition program), 50 residences are managed and used by the National Park Service, and five residences are managed by the National Park Service and leased to individuals (including three to the primary park concessionaire) under fixed-term or lifetime leases. The primary park concessionaire provides approximately 62 housing beds in Wawona. Concession housing includes individual residences, group houses with dormitory-style beds, and tents.

Foresta. Foresta is located to the west of Yosemite Valley and north of El Portal at approximately 5,000 feet in elevation. The community of Foresta is generally considered to extend from near the Foresta Road/Old Coulterville Road junction (near the Foresta wood lot), west to a location near the McCauly Ranch. The Stanislaus National Forest is immediately adjacent to Foresta. The Foresta Association represents Foresta property owners. This group facilitates communications between Foresta property owners, with the objective of presenting a unified position to the National Park Service regarding land-use issues.

Facilities. Foresta is predominately a residential community with no services. Before the 1990 A-Rock Fire, the population of Foresta was made up mostly of individuals who were not employed by the National Park Service or concessionaires. In the summer of 1990, a wildland fire (A-Rock) destroyed many of the homes in Foresta.

Population and Housing. Foresta provides a small amount of housing for National Park Service, concessionaire, and Yosemite Institute employees. Currently, 12 homes located in Foresta are occupied by approximately 25 to 50 residents. All houses in Foresta are small, single-family units. A number of the homes have been rebuilt since the fire, and there are now about 45 homes in Foresta. The National Park Service owned 15 houses in 1990, 14 of which burned.

Yosemite West. Yosemite West is located immediately outside the park boundary and is accessed from the Wawona Road via Henness Ridge Road. The Yosemite West Town Planning Advisory Committee represents community concerns and issues raised by residents throughout the Yosemite West area. The committee is an official body sanctioned by Mariposa County ordinance. As such, the National Park Service recognizes the Town Planning Advisory Committee as the official representative to Mariposa County for the residents of the Yosemite West area.

Facilities. Yosemite West is a small community with few amenities. Currently, in the immediate area of Yosemite West, only about half of the developable lots are built on. Most individuals living in Yosemite West do not work for the National Park Service or the concessionaire. Many are retired, have an external income, and are seasonal residents. Others are home-based business owners. Though outside the park boundary, Yosemite West can be reached only by traveling through the park. Access into and out of the area is available via one road, essentially making the area a cul-de-sac.

Population and Housing. Yosemite West has both permanent and seasonal residents, with a summer population that rarely exceeds 500. Yosemite West is an established subdivision made up of permanent residents, including National Park Service and concessionaire employees, retirees, transient rental owners and their employees, and second homeowners who spend weekends and summers there. Yosemite West property owners have formed the Yosemite West Property and Homeowners, Inc. Housing types range from older, modest cabins to condominiums and large, modern homes. All homes in Yosemite West are privately owned, and many are managed as transient rental properties or as “bed and breakfast” inns. For this reason, many residents act as onsite business owners/operators.

Aspen Valley. Aspen Valley is a small area of private inholdings located on the Old Tioga Road. Historically a resort complex, the area now contains 21 tracts, totaling 5.99 acres. This community consists of summer cabins and people reside there primarily in the summer. There are 24 cabins and approximately 41 smaller structures on lots. The community has limited amenities, in an area that is completely surrounded by Wilderness. There are no schools or businesses in Aspen Valley. Utilities are primitive, consisting of individual generators, wells, and pit toilets.

Services in Yosemite National Park and the El Portal Administrative Site

Fire Protection. The National Park Service has exclusive jurisdiction and sole responsibility for fire protection within Yosemite National Park. The Mariposa County Fire Department may provide assistance during the most serious fires within the park. The National Park Service provides equipment and training, and fire response comes from employee and volunteer members in the Valley, Foresta, and Wawona. In El Portal, the federal land is proprietary interest land, and the National Park Service cooperates with the county to provide area fire protection services. Through a cooperative agreement, the National Park Service provides first response assistance to any fire in the area. The county also operates a volunteer fire protection squad and provides firefighting equipment at El Portal.

Emergency Medical Services. The National Park Service has a concession contract with Doctors Medical Center to provide medical services within the park. A medical clinic is staffed in Yosemite Valley to provide basic medical attention for minor medical conditions, and initial first aid for incidents within the park. For more serious medical conditions, patients are sent to Mariposa or elsewhere for treatment. Rangers, fire management personnel, emergency response volunteers, and the Yosemite Medical Clinic generally provide the first response to medical incidents within Yosemite National Park and the El Portal area (including nonfederal lands). However, at this time, the county is primarily responsible for providing ambulance services. Mariposa County pays the National Park Service $22,000 a year for training to provide medical first responses to the local area outside the park.

Road Maintenance. The National Park Service is responsible for all roadways exclusively on federal property, including most of the access roads within El Portal. The California Department of Transportation (Caltrans) is responsible for the maintenance of Highway 140. Mariposa County is responsible for maintaining paved roads within Section 35 in Wawona. In Foresta, roads are maintained by both the county and National Park Service. The National Park Service retains responsibility for the first mile of paved road leading off of Big Oak Flat Road and for all dirt roads in the community. The county maintains the paved Foresta Road beyond this one-mile mark though Foresta and the dirt continuation of this road down to El Portal. Besides Foresta Road (noted above), the only roadway in the El Portal area under county jurisdiction is the section of Foresta Road from Clark Community Hall east to the boundary of the El Portal Administrative Site.

Environmental Justice

Demographics

The demographic mix of people living in the five counties surrounding Yosemite National Park is similar to that of the state as a whole except numbers of African-American and Asian-American populations are somewhat lower than the state as a whole and American Indian populations are significantly higher (Gramann 1992). A 1990-1991 survey of Yosemite visitors provides the most recent and complete information on the ethnic background of Yosemite visitors; findings are presented in table 3.16. As the table shows, non-Anglo visitors to the park are underrepresented compared to the California population or that of the nation (Gramann 1992).

Table III-16
Ethnic Background of Yosemite Visitors and Residents of California and Yosemite Region

Ethnic Background	Auto Travelers	Bus Travelers	California Residents	Yosemite Region Residents[a]
Anglo	86.6	80.6	57.4	62.7
Hispanic	3.6	4.5	11.6	11.0
Asian	3.3	5.8	9.6	5.0
American Indian	1.4	2.4	0.8	1.5
Other	4.7	2.9	13.1	16.1

a. Yosemite Region includes Madera, Mariposa, Merced, Mono, and Tuolumne Counties.
Source: Dornbusch & Company, Inc. 1999

Annual Household Income

Fire management activities have the potential to affect residents of several communities within the Yosemite region, including El Portal, Wawona, Yosemite Village, Foresta, Yosemite West, and Aspen Valley. As shown in table 3.17, annual household incomes of $20,000 to $39,000 constitute the highest percentage of the region's population (29%), followed by those who make less that $20,000 (26% of the population). Those who make more than $70,000 per year in annual household income are more represented in the region than in the state in general (15% compared to 6%), but how represented they are within the local communities is unknown.

Table III-17
Annual Household Income Category: Yosemite Visitors and Residents of California and the Yosemite Region

<table>
<tr><th>Annual Household Income Category</th><th>Yosemite Visitors</th><th>California Residents</th><th>Yosemite Region Residents[a]</th></tr>
<tr><td>< $20,000</td><td>5%</td><td>37%</td><td>26%</td></tr>
<tr><td>$20,000 – $39,000</td><td>14%</td><td>34%</td><td>29%</td></tr>
<tr><td>$40,000 – $49,000</td><td rowspan="2">21%</td><td>10%</td><td>12%</td></tr>
<tr><td>$50, 000 – $59,000</td><td rowspan="2">13%</td><td rowspan="2">18%</td></tr>
<tr><td>$60,000 – $69,000</td><td rowspan="2">19%</td></tr>
<tr><td>$70,000 – $79,000</td><td rowspan="3">6%</td><td rowspan="3">15%</td></tr>
<tr><td>$80,000 – $99,000</td><td>14%</td></tr>
<tr><td>More than $100,000</td><td>26%</td></tr>
<tr><td>Total</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td colspan="4">a. Yosemite Region includes Madera, Mariposa, Merced, Mono, and Tuolumne Counties.
Source: Dornbusch & Company, Inc. 1999</td></tr>
</table>

Much of the property in Wawona is owned by individuals who claim residence but have property elsewhere. National Park Service and concession employees, and year-round residents, also live in Wawona. Yosemite West also has year-round and seasonal residents. El Portal and Foresta residents are generally either employees of the National Park Service or one of its concessionaires or partners. Yosemite Valley residents are largely National Park Service and concession employees. A large portion of the summer population is represented by the lower salaried, seasonal employee.

Special Designations

Wild and Scenic River Designations

The two major river systems in Yosemite National Park are part of the national Wild and Scenic Rivers System–the Tuolumne River (designated by Congress in the California Wilderness Act in 1984) and the main stem and South Fork of the Merced River (designated by Congress in 1987). These rivers have special protection under the Wild and Scenic Rivers Act, which aims to protect the free-flowing condition and protect and enhance the unique values of designated rivers for the benefit and enjoyment of present and future generations.

The National Park Service prepared the *Merced Wild and Scenic River Comprehensive Management Plan* to ensure that development and use of areas of Yosemite National Park and the El Portal Administration site along the Merced River is consistent with the provisions of the Wild and Scenic Rivers Act. The study delineated river segments and identified presence or absence of Outstandingly Remarkable Values (ORVs) by segment. The *Merced Wild and Scenic River Comprehensive Management Plan* identifies several fundamental elements that are used to evaluate actions in the Merced River corridor, such as boundaries, classification, outstandingly remarkable values, and river protection overlay.

Section 7 determination, management zones, and research and monitoring. These elements must be applied as a set of decision-making criteria to evaluate proposed projects and actions in the Merced River corridor.

Prior to its designation as a Wild and Scenic River, the *Final Environmental Impact Statement and Study Report, Tuolumne Wild and Scenic River*, was completed in October 1979. The National Park Service has not completed a management plan for the Tuolumne Wild and Scenic River, but is in the process of collecting data on relevant natural and cultural resources to be used in the formation of a future *Tuolumne Wild and Scenic River Comprehensive Management Plan*.

Wilderness

The California Wilderness Act designated about 94% (or 704,624 acres) of the park as Wilderness in 1984. An additional 1.5% of the park was designated as potential Wilderness additions. Aside from road corridors and developed areas, the primary non-Wilderness areas of the park are along the southwestern boundary, west of the Tuolumne Grove Road, Big Oak Flat Road, and the Wawona Road. Wilderness in Yosemite is generally defined by the Tuolumne and Merced River drainages, with lands ranging in elevation from 2,900 feet below Wawona to 13,114 feet at the summit of Mt. Lyell.

The National Park Service is required to manage Wilderness in accordance with the Wilderness Act of 1964. The Wilderness act directs managers to "preserve Wilderness character," and mandates that both wildness and naturalness be preserved. Congress defined Wilderness as " ….an area where the earth and its community of life are untrammeled by man," meaning unmanipulated, unmanaged, self-willed, autonomous, wild; that "retains its primeval character and influence."

Congress further defined Wilderness to be an area that is "….managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable…" The Act further stipulates that Wilderness areas must have "outstanding opportunities for solitude or a primitive and unconfined type of recreation."

The Act also states that there shall be no commercial enterprise and no permanent roads within Wilderness, and "except as necessary to meet minimum requirements for the administration of the area for the purpose of the Act" (the purpose defined as preserving Wilderness character and "the public purposes of recreational, scenic, scientific, educational, conservation, and historical use"), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation…" Congress also made a special provision that allows aircraft use "as may be necessary in the control of fire…"

Energy Consumption

Green Energy Parks

In April 1999, the U.S. Department of the Interior entered into a formal Memorandum of Understanding with the Department of Energy to promote the use of energy-efficient and renewable energy technologies and practices in the national parks. This partnership officially inaugurated the program titled "Green Energy Parks: Making the National Parks a Showcase for a Sustainable Energy Future." This initiative will help to fulfill provisions of the Energy Policy Act of 1992, which directs the use of energy-efficient building design and equipment and the use of alternative motor fuels where practicable. It will also help fulfill provisions of two Executive Orders: Executive Order 12902, Energy Efficiency and Water Conservation at Federal Facilities and Executive Order 13031, Federal Alternative Fueled Vehicle Leadership, which promotes increasing the use of alternative-fueled vehicles in the federal motor vehicle fleet.

Energy Consumption in the Fire Management Program

The majority of activities proposed under each of the action alternatives have the potential to effect energy consumption due to of fire management activities, which include use of trucks, heavy equipment, aircraft, drip torches, and other ignition devices.

Changes in Yosemite's fire management program will have little to no influence upon energy use for personal vehicles and/or shuttle bus use, or for housing in Yosemite Valley, El Portal, Wawona, and other locations. Wood from fuels treatment could be made available for use in home heating, reducing the amounts of fuel oil, propane, and electricity used for that purpose, but because of potential inconsistencies with air quality objectives, it would be difficult to justify promoting the use of wood to heat resident's homes. However, many homes are already heated with wood obtained from the National Park Service wood lot (wood available from the removal of tree hazards) or U.S. Forest Service lands (with wood collecting permits).

Topics Dismissed from Further Analysis

Prime and Unique Agricultural Lands. Yosemite does not contain prime and unique agricultural lands. The orchards in Yosemite Valley are managed as historic properties and are discussed under Cultural Landscapes above.

100-year and 500-year Floodplains. The *Draft Yosemite Fire Management Plan/EIS* does not propose permanent development activities in 100-year or 500-year floodplains. General effects within floodplains are considered in the discussion on watersheds.